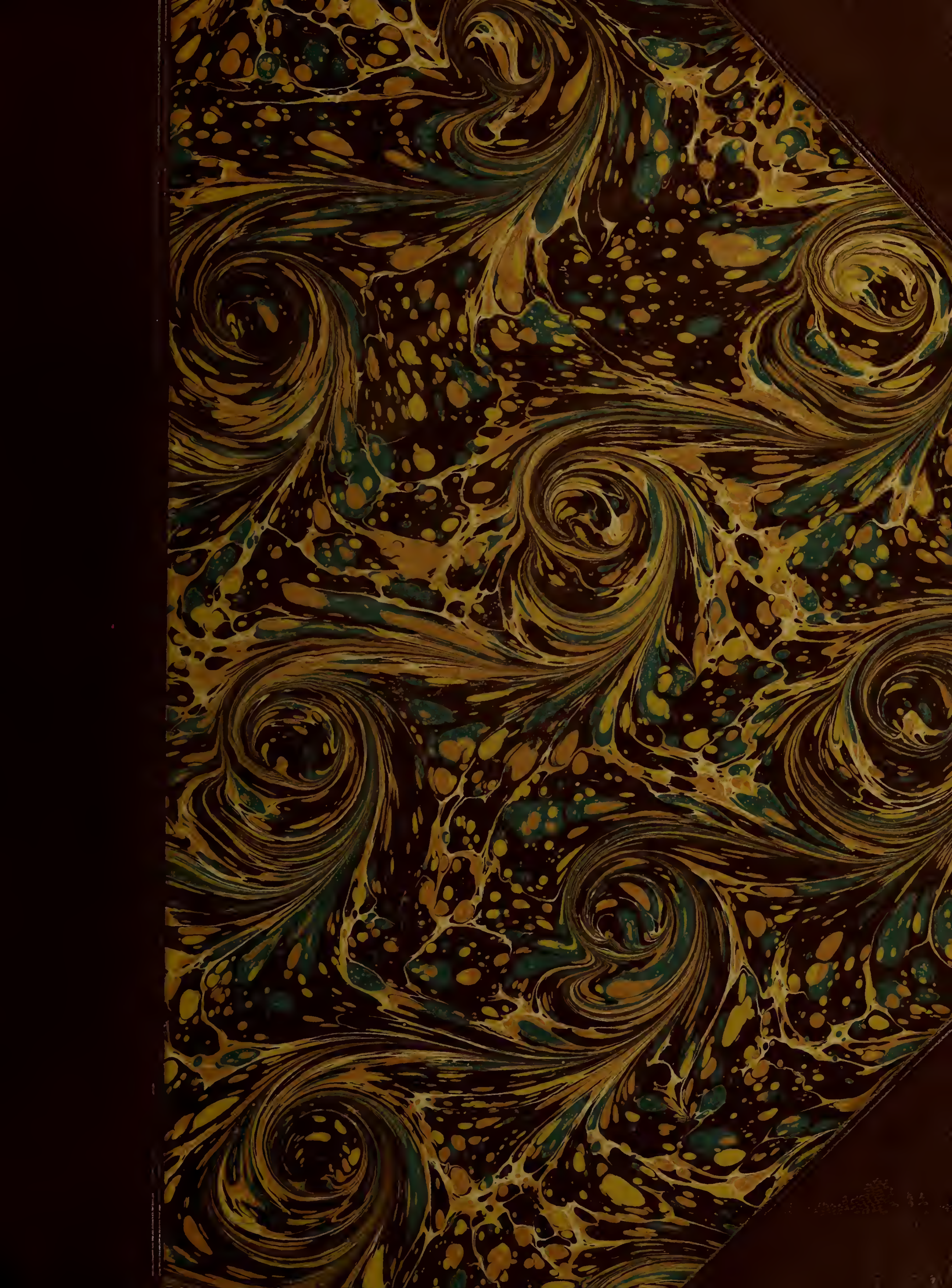

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A

DICTIONARY

OF

CHEMISTRY AND MINERALOGY,

WITH AN ACCOUNT OF THE PROCESSES EMPLOYED

IN MANY OF THE MOST IMPORTANT

CHEMICAL MANUFACTURES.

TO WHICH ARE ADDED A DESCRIPTION OF

CHEMICAL APPARATUS,

AND VARIOUS USEFUL TABLES OF

WEIGHTS AND MEASURES, CHEMICAL INSTRUMENTS, &c. &c.

ILLUSTRATED WITH FIFTEEN ENGRAVINGS.

BY A. & C. R. AIKIN.

VOL. II.

LONDON:
PRINTED FOR JOHN AND ARTHUR ARCH, CORNHILL;
AND WILLIAM PHILLIPS, GEORGE YARD, LOMBARD STREET.
1807.

(W. Phillips, Printer.)

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ERRATA in VOL. II.

Page 30,	line 20 *from the bottom,*	*for* them, *read* it.
33,	3 *from the top,*	*for* urable, *read* durable.
58,	8 *from the bottom,*	*for* formed, *read* found.

J

JADE. See Nephrit.

JARGON. See Zircon.

JASPER.[1] Of this mineral there are, according to Werner, the four following ſubſpecies.

1. *Subſp.* Egyptian Jaſper, Egyptian Pebble. *Egyptiſcher Jaſpis*, Wern. *Jaſpe Egyptien*, Broch.

This Jaſper always exhibits two or more colours in concentric zones or bands, more or leſs regular, with interſperſed ſpots, or dendritic figures. That part neareſt the centre is almoſt always the lighteſt coloured, and is of a yellowiſh-grey paſſing into cream-yellow; the other colours that this mineral exhibits are cheſnut and yellowiſh-brown, more rarely blood-red and browniſh-red. It occurs in rounded pebbles or fragments, the ſurface of which is rough and dull. Internally it is glimmering. Its fracture is between flat conchoidal and ſplintery. Its fragments are indeterminately angular ſharp-edged. It is very ſlightly tranſlucent on the edges. Its hardneſs is ſomewhat inferior to that of quartz; it is brittle and eaſily frangible. Sp. gr. 2.56—2.6.

It is inſuſible before the blowpipe without addition.

It is found abundantly in Egypt and the adjoining deſarts in rolled pieces along with other ſiliceous ſtones, conſtituting a breccia. From the ſoft tone of its colours and the high poliſh that it is ſuſceptible of, it is applied to the ſame ornamental purpoſes as agate.

2. *Subſp.* Striped Jaſper, Ribband Jaſper. *Band Jaſpis*, Wern. *Jaſpe rubané*, Broch.

The colours which this mineral preſents are pearl-grey, greeniſh and yellowiſh grey, yellowiſh and greeniſh white, ochre and Iſabella yellow, fleſh-red, blood and cherry red, and lavender-blue: they are arranged in bands or flame-ſhaped figures, or in veins or dots. It occurs in maſs: is internally dull except where the admixture of foreign particles gives it a ſlight degree of luſtre. Its fracture is conchoidal, ſometimes approaching to ſplintery or earthy: its fragments are indeterminately ſharp-edged. It is opake or ſlightly tranſlucent on the edges. In hardneſs, frangibility, and ſpecific gravity, it agrees with the preceding ſubſpecies.

It occurs in large beds, and in Siberia ſeems to form entire hills. It is found abundantly and very beautiful in Siberia; alſo in Saxony, the Hartz, and Sicily. It receives a high poliſh, and is uſed for ornamental purpoſes.

3. *Subſp.* Porcellanite. *Porzellan Jaſpis*, Wern. *Jaſpe Porcelaine*, Broch.

The colours exhibited by this mineral are ſmoke-grey, yellowiſh and pearl-grey, lilac and lavender blue, orange and ochre yellow, ſtraw, ſulphur, and Iſabella yellow, brick-red, blood and fleſh red, yellowiſh and reddiſh brown, bluiſh and greyiſh black, and rarely mountain-green. It preſents in general only one colour, but is ſometimes ſpotted and clouded. The lavender-blue varieties often contain brick-red vegetable impreſſions. It occurs in maſs and in angular pieces, and is often cracked and rifty. It has a ſlight degree of internal luſtre. Its fracture is imperfectly flat conchoidal, paſſing into uneven and earthy, ſometimes alſo tending to ſlaty. It is opake, leſs hard than the preceding ſubſpecies, very brittle, and eaſily frangible.

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[1] Emmerling, Widenmann, Brochant, Jameſon.

Before the blowpipe it melts *per ſe* into a black ſlag. Its conſtituent parts, according to M. Roſe, are

Silex - - -	60.75
Alumine - -	27.25
Magneſia - -	3.
Oxyd of iron	2.5
Potaſh - -	3.66
	97.16

It forms beds in pſeudo-volcanic hills, and is ſuppoſed to be argillaceous ſchiſtus altered by the combuſtion of beds of coal. It occurs plentifully in Bohemia.

This mineral ſeems to be placed among the jaſpers with little propriety, being eſſentially diſtinct from them by its fuſibility, hardneſs, and geological ſituation.

4. *Subſp.* Common Jaſper. *Gemeiner Jaſpis*, Wern. *Jaſpe commun*, Broch.

The uſual colours of this mineral are browns and reds of various ſhades, alſo lemon, ochre, and Iſabella yellow. It exhibits in general only one colour, but is ſometimes ſpotted, clouded, or ſtriped.

It occurs maſſive and in rolled pieces. Internally it poſſeſſes a ſlight luſtre between vitreous and reſinous. Its fracture is conchoidal, paſſing into even and fine earthy. It is opake, ſometimes ſlightly tranſlucent on the edges. In hardneſs it nearly equals the firſt ſubſpecies. It is brittle and eaſily frangible. Sp. gr. 2.3—2.7.

It is entirely fuſible *per ſe* before the blowpipe.

It occurs in veins in primitive mountains, and in amygdaloid: it is alſo a conſtituent part of certain agate nodules, and in this ſtate is called Jaſper agate.

It is ſuſceptible of a high poliſh, and is in conſiderable requeſt for various ornamental purpoſes.

5. *Subſp.* Opal Jaſper. *Opal Jaſpis*, Wern.

Its colours are reds and browns, rarely ochre yellow. The colour is uniform or diſpoſed in dots, veins, and clouds. It occurs in maſs. Internally it is ſhining with a luſtre between vitreous and reſinous. Its fracture is flat conchoidal. Its fragments are indeterminate and very ſharp edged. It is opake but ſometimes tranſlucent on the edges. Is moderately hard, brittle, and eaſily frangible.

It is found in neſts in porphyry near Tokay in Hungary, in the vicinity of Conſtantinople, and in the Kolyvan mountains in Siberia.

It is the connecting link between jaſper and opal, and is diſtinguiſhable from the preceding ſubſpecies, by the livelineſs of its colours, its ſuperior luſtre, and conſtant conchoidal fracture.

JELLY. See Gelatin.

JET. See Coal.

JEW's PITCH. See Bitumen.

JUICES OF PLANTS. See Sap.

K

KALI. See Carbonat of *Potaſh*.

KALKSPATH. } See Limestone.
KALKSTEIN. }

KALZEDON. See Chalcedony.

KAOLIN. See Clay *Porcelain*.

KARNIOL. See Chalcedony.

KATZENAUGE. *Cat's eye*, Kirw. *Oeil de Chat*. Broch.

Its principal colour is yellowiſh, greeniſh, or aſh-grey; hence it paſſes into yellowiſh-brown, hair-brown, and hyacinth-red; it alſo ſometimes exhibits olive or mountain green and greyiſh-black. When cut and poliſhed it preſents a peculiar play of light reſembling the eye of the animal from which it takes its name. It occurs in rounded and blunt-edged fragments not exceeding the magnitude of a nut. Internally it is ſhining with a reſinous luſtre. Its fracture is ſmall and imperfectly conchoidal, paſſing into lamellar. Its fragments are indeterminately angular, ſharp-edged. It is tranſlucent, rarely ſemitranſparent. Internally there may be obſerved ſmall parallel white fibres, which are the cauſe of its peculiar play of light. It is hard and eaſily frangible. Sp. gr. 2.6.

By expoſure to the heat of a porcelain furnace it loſes its hardneſs, luſtre, and tranſparency, and its colour becomes a pale grey. According to Sauſſure it is fuſible, though with great difficulty, before the blowpipe.

It has been analyſed by Klaproth with the following reſults :

Silex - - -	95·	94·5
Alumine -	1·75	2.
Lime - - -	1·5	1·5
Oxyd of iron	0.25	0.25
	98.50	98.25

Of its geognoſtical ſituation nothing is known with certainty. It is brought to Europe from Ceylon and the Malabar coaſt. It is ſet in rings, and is in conſiderable eſtimation.

KEFFEKIL. See MEERSCHAUM.

KELP. See CARBONAT OF SODA.

KERMES *mineral* is the Hydroſulphuret of ANTIMONY.

KERMES. *Coccus Ilicis*, Linn. Alſo termed by the ancients *Coccus Scarlatinus, Granum Tinctorium.*

The Kermes is a ſmall inſect formerly much uſed in dyeing ſcarlet and different reds, and though its uſe is moſtly ſuperſeded at preſent by the cochineal, it is ſtill employed in ſome parts of Europe, and poſſeſſes very valuable properties as a dyeing material. The beſt kermes was formerly collected in Galatia and Armenia, but it is now chiefly procured from Languedoc in France, and from Spain and Portugal.[a]

The kermes lives on a ſpecies of prickly oak, the female inſect (which is the one uſed) grows to the ſize of a pea, and being of a round bulky form it was long miſtaken for the fruit of the tree, whence it was called grain of kermes, and the ſcarlet dye from it called by the French *Ecarlate de Grain.*

This inſect hangs to the tree by a cottony down. About May or June it has acquired its full ſize, and is then gathered by hand, beginning generally about day-break. A perſon can collect from one to two pounds of it a-day. It is neceſſary to kill the inſect immediately, to prevent the hatching of the ova within its body, which is done by the vapour of vinegar.

When the living inſect is cruſhed it gives a red liquor, an agreeable ſmell, and taſtes bitter and ſharp. It gives a deep red tincture both to water and alcohol.

The colour given by this inſect to woollen cloth is extremely durable, but not ſo brilliant as that of cochineal. The colour does not take on ſilk. (*See the article* DYEING, p. 384.)

KIESELSCHIEFER.[a]

This ſpecies is divided by Werner into the two following ſubſpecies.

1. *Subſp.* Siliceous Schiſtus, Kirw. *Gemeiner Kieſelſchiefer*, Wern. *Schiſte ſiliceux commun*, Broch.

Its principal colour is aſh-grey, bluiſh or greeniſh grey, with occaſional ſpots and ſtripes of red. It is often traverſed by veins of quartz. It occurs in maſs forming whole beds, or in ſmooth rounded pieces. Internally it is dull, rarely a little glimmering. Its fracture in the great is for the moſt part imperfectly ſlaty; in the ſmall is intermediate between ſplintery and uneven, inclining ſometimes to flat conchoidal. Its fragments are ſharp-edged, indeterminate. It is opake, occaſionally ſomewhat tranſlucent on the edges. It is hard, but not very difficult to break, and is moderately heavy.

Before the blowpipe it becomes white and friable. It occurs in thick beds for the moſt part among tranſition mountains; in Bohemia, Saxony, Swiſſerland, the South of Scotland, and Siberia, &c.

Siliceous ſchiſtus appears to have a conſiderable connexion with argillite, and is ſuppoſed by Wiedenmann to be only this ſubſtance hardened by containing a larger proportion than uſual of ſilex. It is one of the numerous rock maſſes on which the appellation Hornſchiefer has been beſtowed by the Germans, a name which has very properly been exploded by Werner.

2. *Subſp.* Lydian Stone. Touchſtone. *Baſanite*, Kirw. *Lidiſcherſtein*, Wern. *Pierre de Lydie*, Broch.

Its colour is greyiſh, paſſing into bluiſh-black. It occurs in maſs and in rounded fragments; and is generally penetrated by veins of Quartz. Internally it is glimmering. Its fracture is even, approaching to conchoidal and ſometimes to ſplintery: in maſs it is generally ſlaty. Its fragments are indeterminate and ſharp edged, often trapezoidal. It is opake, moderately hard, and eaſily frangible. Sp. gr. 2.4 to 2.8.

It is found in ſimilar ſituations with the preceding.

From its hardneſs and colour it is uſed as a touchſtone to aſcertain the comparative purity of the various kinds of gold and ſilver alloys.

Its black colour is affirmed by Humboldt to be cauſed by a portion of carbon.

KILKENNY COAL. See COAL.

KLINGSTEIN.[b] Wern. *Pierre ſonnante*, Broch.

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[a] Emmerling, Brochant, Jameſon.

[b] Jameſon, Brochant.

Its colour is dark greeniſh-grey, paſſing into yellowiſh and aſh grey, or light olive-green or liver brown. It occurs in maſs. The croſs fracture is almoſt dull, the longitudinal fracture is gliſtening. The croſs fracture is ſplintery, paſſing into conchoidal; the longitudinal fracture is more or leſs ſlaty. It breaks into indeterminate ſharp-edged ſometimes tabular fragments. In the great it often occurs in columnar maſſes. It is uſually tranſlucent on the edges. It is conſiderably hard, and not very eaſily frangible. When ſtruck with a hammer it gives a ringing metallic ſound, whence its name. Sp. gr. 2.57.

It melts eaſily before the blowpipe, and gives a clear almoſt colourleſs glaſs.

According to an analyſis made by Klaproth[c] it conſiſts of

Silex - - -	57.25
Alumine - -	23.5
Lime - -	2.75
Oxyd of iron -	3.25
——— manganeſe	0.25
Soda - - -	8.1
Water - -	3.
	98.1

According to Werner it belongs to the floetz trap formation; reſting upon baſalt, into which it frequently paſſes. It often contains cryſtals of felſpar, and then forms ſlate porphyry. It is reckoned by Reuſs to belong to the primitive rocks.

It occurs in the middle mountains of Bohemia; the Donnerſberge in particular, near Milleſchau, a conical mountain above 2500 feet high, conſiſts entirely of this mineral. It has alſo been obſerved by Jameſon in the iſland of Lamlaſh, in the Frith of Clyde. Very beautiful varieties of it alſo occur in rock maſſes between Lanberris and Caernarvon in North Wales.

KOHLENBLENDE. See Coal.

KRAGG. See Basalt.

KREIDE. See Chalk.

KREUTZSTEIN. See Staurolite.

KRISOBERIL. See Chrysoberyl.

KRISOLITH. See Crysolite.

KRYSOPRAS. See Chrysoprase.

KUNKELS PHOSPHORUS. See Phosphorus.

KUPFER NICKEL. See Nickel.

L

LABORATORY. (See the Appendix.)

LABRADOR-STONE. See Felſpar.

LAC-(Gum.) *Lacque*, Fr.

Gum-Lac, as it is uſually termed, is a ſubſtance properly neither a gum nor a reſin, but a very ſingular compound which is prepared by the female of a very minute inſect, the Coccus Lacca, which is found on a few ſpecies of trees in ſome parts of the Eaſt Indies, particularly on the Banyan Fig, and the Rhamnus Jujuba or Biher.[a] [b] The inſect is nouriſhed by the tree, fixing itſelf upon the twigs and extremities of the ſucculent branches, where alſo it depoſits its eggs, which it glues to the branch by a red ſemi-pellucid liquid, the outſide of which hardens in the air and alſo ſerves as a cell for the parent inſect. This gradually increaſes, and when at its greateſt ſize appears as an oval ſmooth red bag, full of a beautiful red liquid. When the eggs are hatched, the young inſects appear firſt to feed upon the incloſed liquid, and after this is expended they eat through the inveſting coat, leaving a hollow red reſinous bag which is the *Stick Lac*. The lac therefore appears in the economy of the inſect to anſwer the double purpoſe of food and protection to the young animal, and when examined each bag is found to be in diſtinct cells like a honeycomb, but of different ſhape.

Lac is an article of great importance in many arts and in commerce. The beſt is procured from the province of Akam, but it is found in great abundance on the uncultivated mountains on each ſide of the Ganges.

The only trouble of collecting the rough or ſtick-lac is that of breaking down the branches and carrying them to market; but for the purpoſe of dying it is taken before the young inſects have eaten their way through the bag, that is while the red liquor remains within it.

The beſt lac is of a deep-red colour, and the liquid within the cells has a ſweetiſh taſte, which in India is uſed immediately as a dye being miſcible with water.

There are four kinds of lac known in commerce, namely—

1. Stick lac, which is the lac in its natural ſtate, without any preparation.

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[a] Kerr in Phil. Tranſ. vol. lxxi.

[b] Saunders in Phil. Tranſ. vol. lxxix.

2. Seed-lac, which is the former kind broken into ſmall lumps, granulated and picked.

3. Lump-lac, which is ſeed lac liquified by fire.

4. Shell-lac, which is the cells of the ſtick lac, liquified by gentle heat, ſtrained and formed into thin tranſparent laminæ in the following ſimple manner.

It is broken into ſmall pieces and picked from the branches and ſticks and put into a canvas bag. This is placed over the fire, and frequently turned till the lac is liquid enough to paſs through its pores, when it is taken off and ſqueezed by two men in different directions dragging it along the convex part of a plantain tree prepared for the purpoſe. The degree of preſſure on the plantain tree regulates the thickneſs of the ſhell.

Of the above three ſorts of lac only the ſtick, ſhell, and ſeed lac are known in commerce.

There is beſides a white or yellowiſh lac brought from Madagaſcar, highly reſembling the pe-la of the Chineſe, which has been very ably examined by Dr. Pearſon, and will be preſently noticed. *(See the next article.)*

The three ſpecies of common lac have lately been analyzed by Mr. Hatchett,[c] and the following is an abſtract of the leading facts and of the general proceſs.

When water is poured on the ſtick-lac coarſely powdered it ſoon begins to turn red, and by heating a crimſon-coloured ſolution is obtained.

Shell-lac loſes by this about 10 per cent. of its weight, and the undiſſolved reſidue becomes yellowiſh-brown.

Seed-lac loſes about 3 per cent. and ſhell-lac no more than $\frac{1}{2}$ per cent.

The watery ſolution contains the colouring *extract*, one of the ingredients of lac, but does not extract the whole at once on account of its intimate union with the other conſtituent parts.

Alcohol diſſolves a large portion of all the kinds of lac. When heat is not uſed the ſolution contains a part of the colouring extract, and a large quantity of a *reſin* which may be ſeparated from the ſolution by evaporation or by adding the ſolution to water, acidulated with muriatic or acetic acid and heating, when the reſin will form a curdy coagulum. The portion ſoluble in *cold* alcohol, and which is entirely reſin, except a little extract, amounts to about 68 per cent. from ſtick-lac, 88 per cent. from fine ſeed-lac, and 81 per cent. from ſhell-lac, but in the latter caſe about 10 more of reſin remain mixed with the other ingredients. Hot alcohol diſſolves alſo other parts of the lac which are not eaſily ſeparable again.

Sulphuric ether diſſolves leſs of lac than alcohol, and is not ſo uſeful in analyſis.

Nitric acid digeſted with lac cauſes it to ſwell much and converts it to a brittle opake yellow ſubſtance, which more of the acid diſſolves after 48 hours digeſtion. The ſolution poured into water ſeparates ſome yellow flocculi which are found to be a kind of *wax*. The remaining liquor is of a bright yellow, contains neither oxalic nor malic acid, and by evaporation leaves a reſinous matter again ſoluble in water. The alkalies ſeparate nothing from this ſolution. This acid therefore operates too powerfully as a chemical agent, rather than a ſimple menſtruum, to be very uſeful in mere analyſis.

Muriatic and acetic acid digeſted on entire lac diſſolve the colouring matter, and another ſubſtance cloſely reſembling *gluten*, but they act but feebly and imperfectly on entire lac, theſe two ſubſtances being protected by the reſin on which theſe acids have ſcarcely any action. This reſin therefore ſhould be previouſly ſeparated by cold alcohol. The preſence of gluten is moſt conſpicuous in ſhell-lac, pieces of which, after the action of alcohol, retain their figure, become more bulky, elaſtic, and nearly white. This led Mr. Hatchett to ſuſpect of the preſence of caoutchouc, but from the circumſtance that boiling water deſtroyed its elaſticity, it was obvious that this ſubſtance was not caoutchouc but gluten.

Potaſh and ſoda, and carbonat of ſoda, completely diſſolve all kinds of lac, and carbonat of potaſh partially. About $\frac{1}{5}$ of the weight of carbonat of ſoda is ſufficient. Theſe ſolutions are ſaponaceous and purple. By repoſe a ſcum or cream riſes to the ſurface, which is part of the wax, and the remainder may be ſeparated by acids.

Lac therefore is found by theſe experiments to conſiſt of a colouring extract of reſin, gluten, and wax, all of them in intimate combination, but ſeparable almoſt entirely by a judicious order and ſelection of the different re-agents.

The general properties of each of theſe ingredients are the following:

1. The extract when dry is of a deep crimſon; ſoluble chiefly but not totally in water, hot or cold; leſs ſo in alcohol, but the reſidue after the action of alcohol diſſolves in water; inſoluble in ether; partially ſoluble in muriatic and acetous acid, giving a red liquor which is changed

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[c] Phil. Tranſ. for 1804, p. 191.

to purple by alkalies; is totally ſoluble in acetic acid; and equally ſo in the alkalies. When pure alumine is put into the aqueous ſolution, and a few drops of muriatic acid added, a beautiful coloured lake is precipitated. A fine precipitate is alſo formed by muriat of tin.

2. The reſin is browniſh yellow, ſoluble in alcohol, ether, acetic acid, nitric acid, potaſh, and ſoda, and is precipitable by water from all theſe ſolvents except the two laſt.

3. The gluten is obtainable in two ways: if the pieces of lac after digeſtion in alcohol be digeſted with dilute acetic or muriatic acid, moſt of the gluten is diſſolved, and may be precipitated by alkalies added in due proportion; but is rediſſolved by an exceſs of them, and then is ſeparable by acids. It much reſembles the gluten of wheat.

4. The wax is found floating like oil on the ſolution of lac after long boiling in nitric acid, which takes up every thing elſe, and congeals when cold; or it may be more eaſily procured, by firſt digeſting the lac with cold alcohol, and treating the reſiduum with boiling nitric acid, which will ſeparate the wax.

Thus obtained it is white, of the conſiſtence of bees wax, melts at a leſs heat than boiling water, and burns with a white flame and ſmell like ſpermaceti. It is inſoluble in cold alcohol, but with a boiling heat a portion is diſſolved, moſt of which ſeparates by mere cooling, and the remainder by affuſion of water. Potaſh boiled with the wax forms a milky ſolution, but the chief part of the wax floats at the top, and ſeems to be converted into a kind of ſoap, hardly ſoluble, and inflammable. Acids ſeparate the remainder of the wax from the alkaline ſolution.

Ammonia diſſolves a ſmall portion of the wax; nitric and muriatic acid none. This wax bears the ſtrongeſt analogy with the wax of the Myrica or Candleberry Myrtle. (*See the article Wax.*)

Stick lac was analyzed by Mr. Hatchett in the following way.

A. 200 grains were repeatedly digeſted in boiling water, and the red ſolution evaporated, left 18 grains of extract.

B. The reſidue of the laſt proceſs was digeſted in repeated portions of alcohol, without heat for forty-eight hours, and theſe ſolutions evaporated, gave 136 grains of reſin.

C. The reſidue of the laſt was again digeſted in boiling water, and 2 grains more of extract were obtained.

D. The reſidue of the laſt was boiled with one ounce of muriatic acid, with two of water, and the ſolution ſaturated with carbonat of potaſh which gave a precipitate of 11 grains when dry, which was gluten.

E. The reſidue from the laſt conſiſted of wax entangling bits of twigs and other accidental impurities. Part of it was ſeparated by melting and ſtraining through linen, and the remainder was boiled with potaſh. The whole wax thus obtained was 12 grains, and 13 grains of the impurities remained.

The ſhell lac was analyſed in a more complex way, the reſin and wax being more intimately united in this ſpecies of lac than the others, and on account of its texture not being reducible to fine powder. The proceſſes A. B. C. D. being repeated as in the laſt, the reſidue was digeſted ſome days in the cold, in three ounces of acetic acid, after which half a pint of alcohol was added, and the whole heated, whereby the wax was ſeparated in a very pure ſtate. The aceto-alcoholic tincture which was brown was then poured into water, which became milky, and being heated and filtered, more reſin ſeparated in a curdy form. The remaining clear liquor was then ſaturated with carbonat of potaſh, and a further portion of gluten was obtained.

The three different ſpecies of lac being analyzed, gave the following proportions: 100 parts of ſtick-lac gave 68 of reſin, 10 of colouring extract, 6 of wax, 5.5 of gluten, and 6.5 of extraneous ſubſtances: 100 parts of ſeed-lac gave 88.5 of reſin, 2.5 of extract, 4.5 of wax, and 2 of gluten: 100 parts of ſhell lac gave 90.9 of reſin, 0.5 of extract, 4. of wax, and 2.8 of gluten.

Lac is employed for a variety of purpoſes in the arts, both in India and elſewhere.[d] The finer pieces of ſhell-lac are cut into ornaments of various kinds, ſuch as beads and necklaces; the ſhell-lac enters largely into the compoſition of ſealing wax, and hard japans or varniſhes, hence called *lacquers*, and lac is alſo uſed for dyeing. For this laſt the ſtick-lac is the only kind employed, as the colouring matter chiefly reſides in the extract, of which the ſhell-lac contains a very ſmall proportion, but on the other hand as this has much more reſin, it is greatly preferable for varniſhes and lacquers. A compoſition of rough angular ſand melted with lac is much employed in India as the material for grindſtones, which are caſt into a circular ſhape, and when well managed, they cut very faſt. The lapidaries uſe corundum

[d] Kerr.

powder inſtead of ſand, and form with lac a compoſition for grinding and poliſhing gems.

LAC (*White*). LACCIC ACID. A white or yellowiſh-white waxy matter, the production of inſects, and called in Madras *White lac*, was firſt particularly noticed by Dr. Henderſon about the year 1786, and ſuppoſed by him to reſemble very cloſely the *Pe-la* of the Chineſe, or white wax uſed in varniſhes, for candles, &c. Some of this white lac ſent over to England about the year 1793, was examined by Dr. Pearſon with the following reſults.[a]

The white lac is in grey, opake, rough, roundiſh pieces, of about the ſize of a pea. It has a ſaltiſh and bitteriſh taſte, but when freſh gathered it appears from Dr. Anderſon's account to have a ſweetiſh and delicious flavour. On preſſing the pieces between the fingers, a ſaltiſh liquid oozes out. White lac has no ſmell unleſs when rubbed. After melting and ſtraining it ſinks in water.

When heated in water it melts at 145°, and then a reddiſh liquid ſeparates from the lac and mixes with the water. This liquid has the following properties. It gives inſtantly a red colour to litmus; its ſpecific gravity is 1025; its taſte is ſaltiſh but not ſour. Evaporated conſiderably it depoſits ſmall needle-like cryſtals mixed with a ſlimy ſediment. The liquor on diſtillation gives a clear fluid which diſſolves chalk and carbonat of ſoda with effervеſcence, and in ſo doing it becomes neutralized, and no longer turns litmus red. By heat the whole of this ſubſtance is volatilized and deſtroyed, giving only the common products of animal matter. From its reddening litmus and neutralizing the alkaline and earthy carbonats, this ſubſtance is inferred to be an acid, and from its deſtructibility by heat it probably belongs to the claſs of animal or vegetable acids, but it does not accurately agree with any of the other acids in all its properties. It is therefore either ſome known acid modified in its chemical properties by union with ſome other part of the lac, or elſe it is a peculiar acid to which the term *laccic acid* may be given.

The whitiſh lac remaining after the acid or ſaline liquid has been thoroughly ſeparated by waſhing was of the colour of bees-wax, and hard and brittle as reſin. On digeſting it with ſolution of potaſh, Dr. Pearſon found that it became brown, gave a ſmell like palm-oil, and united with the alkali to a coagulated maſs, but could not be brought to the ſtate of a true ſoluble ſoap. The ſolution was decompoſed by acids. Ammonia had nearly the ſame effect as potaſh. Candles were made of this ſubſtance with cotton wicks, which burned rapidly, and gave much ſmoke and a reſinous ſmell. In this reſpect it differs from the Chineſe pe-la, which burns as well as the fineſt wax, and with as little ſmoke.

When the white lac was heated with nitric acid much nitrous gas was given out, and a perfect ſolution was obtained, but on cooling nearly the whole ſeparated, quite white, ſcarcely any being found to remain in the acid liquor. The hot nitrous ſolution alſo gave a copious precipitation when poured into water. This lac was totally diſſolved in five parts of oil of turpentine, but the ſolution grew turbid as it cooled. Ether diſſolved a tenth of its weight of this lac, but imperfectly. Alcohol diſſolved by repeated affuſion all but 15 per cent. of this lac; the hot ſaturated ſolution became opake and thick by cooling, but when ſpread on paper it did not leave a bright and ſmooth varniſh.

By various other experiments this lac appeared to have the greateſt chemical analogy with bees-wax, though it differed from it in a few particulars.

If obtained largely it probably might prove of much uſe in the arts.

LAC SULPHURIS is ſulphur ſeparated by acids from its alkaline ſolution. It is ſomewhat altered in the proceſs, and changes its lemon-yellow colour for a grey or yellowiſh-white like cream.

It is thought to be ſomewhat milder as a medicine. (*See* SULPHUR.)

LACTIC ACID. See MILK.

LAKES. A lake may be defined to be an intimate combination of colouring extract, with an earth or metallic oxyd formed by precipitation from the ſolution of the colouring matter. Thus if a ſolution of alum is added to an infuſion of madder a mutual decompoſition takes place, and part of the alumine falls down intimately united with the colouring matter of the madder. This ſeparation is much aſſiſted by an alkali.

The lakes form ſome of the beautiful pigments, and are much uſed in water-colour painting and other purpoſes. They are almoſt invariably compoſed either of alum, or ſometimes the ſolutions of tin, and ſome other watery ſolution of a colouring matter. The moſt important are deſcribed under the articles *Carmine*,

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[a] Phil. Tranſ. vol lxxxiv.

Cochineal, *Madder*, *Brazil-Wood*, and ſome other of the colouring materials.

LAMP-BLACK. There are two ſpecies of lamp-black in common uſe; one is the light ſoot from burning wood of the pine and other reſinous kinds, and the other is a heavy black prepared from bones by calcining them in *cloſe* veſſels.

(For the former kind ſee the articles Charcoal and Turpentine, and for the latter the article Bone. Ivory-black is of the ſame ſpecies with that from bone.)

LAPIS CALAMINARIS. See Calamine.

LAPIS INFERNALIS. See Lunar Cauſtic.

LAPIS LAZULI. *Lazurſtein*, Wern. *Pierre d'Azur*, Broch.

The colour of this mineral is Pruſſian-blue, ſmalt-blue, or ſky-blue. It occurs in maſs, diſſeminated, or in rolled pieces. It poſſeſſes a faint-glimmering luſtre. Its fracture is fine grained uneven. Its fragments are indeterminately angular. It is generally tranſlucent on the edges. Its hardneſs is ſuperior to that of glaſs. It is brittle and eaſily frangible. Sp. gr. 2.76 to 2.94.

It efferveſces ſlightly with acids when pulverized. Before the blowpipe it loſes its colour and runs into a whitiſh enamel. When calcined, and then treated with the mineral acids, it forms with them a gelatinous maſs. When heated it becomes phoſphoreſcent. A low red heat does not impair its colour. It has been analyzed by Klaproth,[a] and appears to conſiſt of

Silex - - -	46.
Alumine . -	14.5
Carbonat of lime -	28.
Sulphat of lime -	6.5
Oxyd of iron -	3.
Water - - -	2.
	100.0

This beautiful mineral is ſaid to be found in a vein accompanied by garnet, felſpar, and pyrites, near the lake Baikal in Siberia. It is alſo found in Chineſe Tartary. Alſo in Perſia, Bucharia, and the Iſland Hainan in the Chineſe ſea. It generally occurs mixed with felſpar, quartz, and iron pyrites, which laſt was formerly miſtaken for ſpecks and ſpangles of native gold.

From its colour, and the high poliſh that it is capable of receiving, it is uſed in various ornamental work, ſuch as inlaying, ſeal-ſtones, &c. It is alſo highly valued by painters, as affording that beautiful and permanent, but expenſive pigment, ultramarine blue.

LAPIS LYDIUS. See Kieselschiefer.

LAPIS OLLARIS. See Potstone.

LAVA. *Lave*, Broch.

The colour of lava is greyiſh or greeniſh-black, greeniſh-grey, or yellowiſh-grey. It is ſpotted externally reddiſh or yellowiſh brown, yellowiſh-white, or ſulphur-yellow. It occurs porous, carious, or veſicular. Its luſtre is vitreous, more or leſs gliſtening. Its fracture is imperfectly conchoidal, paſſing into fine grained uneven. It is ſlightly tranſlucent at the edges. Is moderately hard, brittle, eaſily frangible, and light. It generally attracts ſtrongly the magnetic needle. It is eaſily fuſible into a black compact glaſs.

It generally incloſes other foſſils, eſpecially cryſtals of felſpar, augite, hornblende, and leucite.

It is the product of Etna, Veſuvius, Hecla, and other volcanoes.

On account of its lightneſs it is much employed in building; and when diſintegrated by the action of the air forms a ſoil of remarkable fertility.

LAVA GLAS. See Chalcedony.

LAZULITE. *Lazulith*, Wern. *Lazulithe*, Broch.

The colour of this mineral is a deep ſmalt-blue. It occurs diſſeminated in fine grains or maſſes of the ſize of a hazle-nut. The latter often preſent the appearance of ſhort tetrahedral priſms. Its fracture is uneven with a glimmering luſtre. It is opake, paſſing to tranſlucent. When pulverized it has a bluiſh-white colour. Its hardneſs is nearly equal to that of quartz. It is brittle, and eaſily frangible.

At a red heat it loſes its colour and becomes grey. It is infuſible *per ſe* before the blowpipe, but with borax runs into a clear yellow glaſs. It is with difficulty acted on by the acids, and its colour is unalterable by cauſtic alkali, at the common temperature. It contains, according to Klaproth, ſilex, alumine, and oxyd of iron, but neither carbonat nor ſulphat of iron.

It occurs at Vorau in Auſtria, mixed with quartz, and forming a ſmall vein in micaceous ſchiſtus.

LAZULITE (of Hauy). See Lapis Lazuli.

LAZURSTEIN. See Lapis Lazuli.

LEAD. *Plumbum*, Lat. *Plomb*, Fr. *Bley*, Germ. *Saturnus*, Alchem.

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[a] Analyt. Eſſ. I. p. 168.

Lead[*] is a metal of a bluiſh-grey colour, is malleable, ductile, and inelaſtic: it is very ſoft, is fuſible at leſs than a red heat, is eaſily oxydable by expoſure to the air when melted, and its oxyd is eaſily fuſible into a tranſparent yellow glaſs.

§ I. *Ores of Lead.*

Sp. I. Galena.

Of this there are the two following ſubſpecies.

I *Subſp.* Common Galena. *Gemeiner Bleiglanz,* Wern. *Galène,* Broch. *Plomb Sulfuré,* Hauy.

Its colour is a more or leſs perfect lead-grey, inclining in ſome varieties to blackiſh; it ſometimes preſents ſuperficially an irideſcent tarniſh. It occurs in maſs, diſſeminated or inveſting; alſo in particular ſhapes, ſuch as globular, reniform, ſpecular, reticulated, cellular, cylindrical, &c. alſo cryſtallized.

The primitive cryſtalline form of galena is the cube, beſides which it preſents the following varieties.

1. The cube with its ſolid angles replaced by triangular planes.
2. The cube elongated and its ſolid angles replaced by pentagonal planes.
3. The perfect octohedron.
4. The preceding with the edges replaced by long pentagonal planes.
5. The octohedron with the ſolid angles doubly truncated.
6. The octohedron ſingly truncated on the ſolid angles, and doubly or trebly truncated on the edges.

The cryſtals are rarely large, but generally middle-ſized or ſmall; either grouped one upon the other, implanted, or ſolitary. Their planes are commonly ſmooth, ſometimes druſy, rarely carious or rough. The external luſtre of galena varies, according to its ſurface, from reſplendent and ſpecular to glimmering. Internally it varies from ſpecular to gliſtering, and its luſtre is metallic. Its fracture is lamellar, either plane, curved, or divergent; this latter paſſes into radiated, the rays being ſhort and broad. It is diviſible in a three-fold rectangular direction, hence its fragments are cubical. When in maſs it is often compoſed of granular and rarely of lamellar diſtinct concretions. It is ſoft, ſomewhat ſectile, eaſily frangible. Sp. g. 6.56 to 7.78.

Before the blowpipe it decrepitates, then melts, giving out a ſulphureous odour, and when this ceaſes a globule of metallic lead remains behind.

Galena conſiſts eſſentially of lead and ſulphur in the proportion of about 100 of the former to 15 of the latter, but beſides theſe ingredients, iron pyrites, grey antimony, copper, gold, and ſilver, are found in various proportions, beſides different earthy ingredients, chiefly lime and ſilex. The following are ſome of the moſt recent and accurate analyſes that have been made of this ore.

	From Kirſchwald, in Deux Ponts.	Kampfſtein.	Ecklerberg.	Kantenbach.	Cologne.
Lead	54.	69.	68.69	64.	63.1
Sulphur	8.	16.	16.18	18.	12.
Carbonated lime and ſilex	38.	15.	16.13	18.	19.67
Oxyd of iron	0	0	0	0	3.33
	100	100	101	100	98.1

The above analyſes were made by Vauquelin, to which we ſhall ſubjoin an analyſis of galena from Durham, by Dr. Thomſon.

Lead	85.13
Sulphur	13.02
Oxyd of iron	0.5
	98.65

The proportion of ſilver in galena varies greatly, from $\frac{1}{100}$ or leſs to $\frac{1}{12}$; it is obſervable that the preſence of this metal conſiderably impairs the luſtre of galena, and that it is much more frequently found in the octohedral than in the cubical varieties of this mineral. The preſence of antimony is commonly indicated by a tendency to the radiated fracture.

It is next to pyrites the moſt common of metallic ores, and is found in beds and veins in primitive, tranſition, and ſecondary mountains. It occurs moſt abundantly in argillaceous ſchiſtus and ſecondary limeſtone, and is almoſt always accompanied by blende and calamine. To enumerate the places where it is found, would be to mention almoſt all the mineral diſtricts that are known: we ſhall content ourſelves therefore with pointing out the principal mines of this ſubſtance in Britain.

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[*] Emmerling, Lenz, Hauy. Brochant, Kirwan, Jameſon.

Theſe are ſituated in Cornwall, Devonſhire, and Somerſetſhire; in Derbyſhire, in Durham, and the contiguous boundaries of Lancaſhire, Cumberland, and Weſtmoreland; in Shropſhire, in Flint and Denbighſhire, in Merioneth and Montgomeryſhire; at the lead-hills in Scotland on the borders of Dumfriesſhire and Lanarkſhire, in Ayrſhire, and at Strontian in Argyleſhire.

Moſt of the lead of commerce is procured from this ore; it is alſo made uſe of without any further preparation as a glazing for coarſe pottery.

2. *Subſp.* Compact galena. *Bleiſchweif,* Wern. *Galène compacte,* Broch.

Its colour is ſimilar to but generally ſomewhat lighter than that of the preceding ſubſpecies. It occurs in maſs, diſſeminated and ſpecular (the ſpecular in Derbyſhire is known by the name of *ſlikenſide*). The ſpecular variety is ſplendent externally, the others are only glimmering. Internally all the varieties are ſlightly gliſtening with a metallic luſtre. Its fracture is even, paſſing into flat conchoidal. Its fragments are indeterminately angular. It acquires a poliſh by friction; is more tender than the preceding ſubſpecies, and agrees with it in the reſt of its characters. Sp. gr. 7.44.

In its habitudes with the blowpipe it differs from common galena in not decrepitating on the firſt application of heat.

It occurs in veins with common galena, and always occupies the ſides of the vein. It is not very common.

Sp. 2. Triple Sulphuret of Lead.[c]

Its colour is dark grey inclining to black. It occurs cryſtallized. Its primitive figure is a rectangular tetrahedral priſm, beſides which it preſents the following varieties.

1. The primitive cryſtal with the ſolid angles replaced by triangular planes.
2. The ſame with its lateral edges replaced by rectangular planes, forming an eight-ſided priſm.
3. The ſame terminated by a very low and deeply truncated tetrahedral pyramid.
4. Four priſms with deeply truncated dihedral ſummits joined to each other at their baſes, forming a rectangular croſs.

The planes correſponding with the lateral faces of the original priſm are longitudinally ſtriated, the others are ſmooth. The cryſtals are large and middle-ſized, with a ſplendent metallic luſtre both externally and internally. Its fracture is coarſe-grained uneven. In hardneſs it ranks between calcareous and fluor ſpar; is very brittle and eaſily frangible. It leaves a faint black trace when rubbed on paper. Sp. gr. 5.76.

When ſuddenly heated before the blowpipe it crackles and ſplits, but if gradually heated it melts, and on cooling forms a globule of a dull metallic-grey colour; by further expoſure to the flame a white and ſomewhat ſulphureous vapour is diſengaged, conſiſting of ſulphur and antimony, and there remains behind a cruſt of ſulphuretted lead, incloſing a globule of metallic copper. It has been analyzed by Mr. Hatchett with the following reſult.

17.	Sulphur.
42.62	Lead.
24.23	Antimony.
12.8	Copper.
1.2	Iron.
97.85	
2.15	Loſs.
100.	

It has hitherto been found only in the mine Huel-Boys, in Cornwall.

Sp. 3. Blue Lead Ore. *Blaubleyerz,* Wern. *Mine de Plomb bleue,* Broch.

Its colour is intermediate between lead-grey and indigo-blue; it alſo paſſes ſometimes to ſmoke-grey and black. It occurs ſometimes in maſs, but uſually cryſtallized in ſmall ſix-ſided priſms, perfectly equiangular, often a little bulging, and the external ſurface of which is ſomewhat rough and dull. Internally it poſſeſſes a feebly-glimmering metallic luſtre. Its fracture is even, paſſing into fine-grained uneven and flat conchoidal. Its fragments are indeterminately angular. It is opake, gives a ſhining metallic ſtreak, is ſoft, ſomewhat ſectile, and eaſily frangible. Sp. gr. 5.46.

It fuſes readily before the blowpipe, then burns with a weak blue flame, giving out a penetrating ſulphureous vapour, and is reduced to a metallic globule.

It has not been regularly analyzed. Klaproth diſcovered in it ſome phoſphoric acid, and the other conſtituent parts are probably ſulphur and oxyd of lead.

It has hitherto been found only at Zſchoppau in Saxony, in veins accompanied by black and brown lead ores, carbonat of lead, malachite, quartz, fluor ſpar, and heavy ſpar.

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[c] Phil. Tranſ. 1804, p. 30.

Sp. 4. Carbonat of Lead. *Weiſs Bleyerz*, Wern. *Mine de Plomb blanche*, Broch.

Its colour is greyiſh or yellowiſh-white, yellowiſh-grey, cream-yellow, and light clove-brown, ſometimes though rarely dark aſh-grey. It occurs maſſive, diſſeminated, and ſuperficial; but moſt frequently cryſtallized. Its primitive figure is a rectangular octohedron, diviſible parallel to the common baſe of the two pyramids of which it is compoſed. The chief varieties of cryſtallization that it exhibits are,

1. The cuneiform octohedron.
2. The pyramidal dodecahedron.
3. The preceding with a ſix-ſided priſm interpoſed between the pyramids.
4. The ſame as var. 3. with ſummits of the terminal pyramids replaced by a ſix-ſided plane.
5. A ſix-ſided priſm with the ſummits compoſed of four planes, the oppoſite ones being equal and ſimilar.
6. The ſame with the ſummits compoſed of ſix planes, the correſponding ones being equal and ſimilar.

The cryſtals are uſually ſmall, rarely middle-ſized, either ſolitary or in groups: their ſurface is generally ſpecular and ſplendent, ſometimes a little rough or ſtriated, and then only gliſtening. Internally its luſtre varies from highly reſplendent to gliſtening, and is that of the diamond, inclining on the one hand to ſemi-metallic, and on the other to reſinous. Its fracture is ſmall conchoidal, paſſing into fine-grained uneven and fine ſplintery or imperfectly fibrous. Its fragments are indeterminately angular. It varies from tranſparent to tranſlucent, and is in a remarkable degree doubly refracting. It is ſoft, brittle, and eaſily frangible. Sp. gr. 6.0 to 7.2.

Before the blowpipe it decrepitates, becomes yellow and then red, and if heated on charcoal is immediately reduced. It efferveſces ſlightly in cold nitrous or muriatic acid, but more vigorouſly if the menſtruum is warmed. It is blackened by hydroſulphuret of ammonia. It is often confounded with columnar heavy ſpar, but may be readily diſtinguiſhed from this by its ſuperior ſpecific gravity and its habitudes with the blowpipe and hydroſulphuret of ammonia. There are ſeveral analyſes of this ore, but perhaps the moſt ſatisfactory are the following.

From Zitterfeld, by Weſtrumb.	
Oxyd of lead	81.2
Carbonic acid	16.
Oxyd of iron	0.3
Lime - - -	0.9
	98.4

From Lead-hills, by Klaproth.	
77	Lead
5	Oxygen
16	Carbonic acid
2	Water and loſs
100	

Carbonat of lead is almoſt always accompanied by galena, and appears to be more frequently found in argillaceous ſchiſtus than in any other kind of rock. It is by no means a rare mineral, but ſeldom occurs in ſufficient quantity to be worth ſeparating from the adhering ſpar, &c. for the purpoſe of ſmelting. The fineſt ſpecimens of this ore that are found in Britain come from the mines of Derbyſhire, of Lead-hills in Scotland, and Minera in Denbighſhire, at which laſt place the compact variety is remarkably abundant.

Sp. 5. Black Lead Ore. *Schwartz Bleyerz*, Wern. *Mine de Plomb Noir*, Broch.

Its colour is greyiſh-black paſſing into ſmoke-grey. It occurs in maſs, diſſeminated or cellular, or cryſtallized in ſix-ſided priſms, either ſimple or terminated by dihedral ſummits.

The cryſtals are ſmall and grouped confuſedly in druſes. Their ſurface is ſometimes ſmooth, ſometimes ſtriated longitudinally. Externally it is ſplendent or ſhining. Internally it is ſhining or gliſtening, with a luſtre approaching to ſemi-metallic. Its fracture is fine-grained uneven, paſſing into imperfectly conchoidal. Its fragments are indeterminately angular. It is opake, or at moſt tranſlucent on the edges. It gives a greyiſh-white ſtreak; it is moderately hard, brittle, and eaſily frangible. Sp. gr. 5.77.

Before the blowpipe it decrepitates, and is quickly reduced to a metallic globule. It has recently been analyzed by Lampadius, and appears to conſiſt of

72.	Lead
7.	Oxygen
18.	Carbonic acid
2.	Carbon
99	

It occurs in veins of galena, principally of the moſt recent formation. It uſually occupies the upper part of the vein, incruſting galena, and being itſelf covered by carbonat or green phoſphat of lead. It is found in the Lead-hills in Scotland; in Bohemia and Saxony; in Brittany in France, and in Siberia.

Sp. 6. Muriat of Lead.[b] *Corneous Lead Ore,* Jameſon. *Hornblei,* Karſten.

Its colour varies from the paleſt grey to wine-yellow. It occurs cryſtallized in cubes, either ſimple or terminated by tetrahedral pyramids, or bevelled on the edges. The cryſtals are middle-ſized and ſmall, and have a ſplendent vitreous luſtre. The principal fracture is foliated, the croſs fracture conchoidal. It is tranſparent or ſemi-tranſparent. It is much ſofter than carbonated lead; and is eaſily frangible. Sp. gr. 6.05.

When heated on charcoal before the blowpipe it runs into an opake orange-coloured globule, which on cooling becomes firſt yellow and then white. At a high heat the globule ſuddenly ſpreads over the charcoal, the acid flies off in vapours, and there remain behind minute grains of metallic lead.

It has been analyzed by Klaproth and Mr. Chenevix with the following reſults.

85.5	——	85	Oxyd of lead
8.5	——	8	Muriatic acid
6.0	——	6	Carbonic acid
100.0		99	

It has hitherto been found only at Matlock in Derbyſhire, upon galena.

Sp. 7. Brown Phoſphat of Lead. *Braun Bleyerz,* Wern. *Mine de Plomb brune,* Broch.

Its colour is hair-brown, paſſing on one ſide into grey, and on the other into clove-brown. It occurs rarely in maſs, but generally cryſtallized in lengthened ſix-ſided priſms, ſometimes ſo ſlender as to become capillary. The ſurface of the cryſtals is blackiſh and rough: internally it is gliſtening, with a reſinous luſtre. Its fracture is ſmall grained uneven paſſing into fine-ſplintery. Its fragments are indeterminately angular. It is more or leſs tranſlucent, gives a white powder, is ſoft, moderately brittle, and eaſily frangible. Sp. gr. 6.6 to 6.9.

Before the blowpipe it melts very eaſily, but is not reduced to the metallic ſtate; by cooling concretes into a radiated maſs. It does not effervеſce with acids.

According to Klaproth it conſiſts of

Oxyd of lead - -	78.58
Phoſphoric acid -	19.73
Muriatic acid - -	1.65
	99.96

It occurs in veins at Huelgoet in Brittany, at Mieſs in Bohemia, near Schemnitz in Hungary, Saſka in the Bannat, and Zſchoppau in Saxony.

Sp. 8. Green Phoſphat of Lead. *Grün Bleyerz,* Wern. *Mine de Plomb verte,* Broch.

Its uſual colour is olive-green, but it alſo exhibits ſeveral other ſhades of green, ſuch as graſs-green, greeniſh-white, piſtachia, and yellow green, whence it paſſes into ſulphur-yellow. It occurs ſometimes in maſs, or reniform or botryoidal, but moſt commonly cryſtallized.

Its primitive form is the pyramidal dodecahedron, conſiſting of two ſix-ſided pyramids joined at their baſes. The varieties of cryſtallization which it has been found to exhibit are

1. The regular hexahedral priſm.
2. The ſame, with the lateral edges replaced by rectangular planes, thus forming a dodecahedral priſm.
3. The hexahedral priſm terminated at each extremity by a hexahedral pyramid.
4. The ſame with the apex of the terminating pyramid replaced by a hexagonal plane.

The cryſtals are generally ſmall and very ſmall, either ſolitary or in groups. Sometimes the cryſtals are ſo minute as to appear like a fine down.

The ſurface of the cryſtals is ſmooth and ſhining; internally they are gliſtening, with a reſinous luſtre. The fracture is ſmall-grained uneven, verging ſometimes upon ſplintery. Its fragments are indeterminately angular. It is tranſlucent, very rarely ſemi-tranſparent. Its hardneſs is ſuperior to that of carbonated lead; it gives a greeniſh-white powder, is brittle, and eaſily frangible. Sp. gr. 6.2 to 6.9.

Before the blowpipe it becomes of a greyiſh-white and melts very eaſily, without decrepitation, into a globule; but ſhows no ſigns of reduction. If the globule is cooled ſlowly it forms a polyhedral ſtriated ſolid. It is ſoluble difficultly, and without effervеſcence in the mineral acids.

The three ſubſequent varieties of this mineral have been analyzed by Klaproth with the following reſults.

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[b] Nicholſon's Journal, 4to. iv. p. 219. Klapr. Analyt. Eſſ. ii. p. 111,

Yellowiſh-green phoſphat, from Zſchoppau.	Graſs-green phoſphat, from Hoffsgrund in the Briſgau.	Lemon-yellow phoſphat, from Wanloch-head.	
78.	77.1	80.	Oxyd of lead
18.37	19.	18.	Phoſphoric acid
1.7	1.54	1.62	Muriatic acid
0.8	0.1	0.	Oxyd of iron

A ſpecimen from Erlbach on the other hand was found by Vauquelin to contain

45.18	Lead
18.7	Phoſphoric acid
4.05	Oxygen
32.	Silex
99.93	

This mineral is found in veins both in primitive and ſecondary mountains, but chiefly in the former of theſe. It is accompanied for the moſt part with galena, carbonat of lead, and iron ochre, with quartz, heavy ſpar, and calcareous ſpar.

It is met with in Bohemia, Saxony, Bavaria, the Briſgau, France, Scotland, and Siberia.

Sp. 9. Sulphat of Lead. *Blei Vitriol*, Wern. *Vitriol de Plomb natif*, Broch.

Its colour is greyiſh or yellowiſh-white, paſſing into ſmoke and aſh-grey. It has been found only cryſtallized. Its primitive figure is an octohedron, compoſed of two tetrahedral pyramids with rectangular baſes; the other varieties are

1. The cuneiform octohedron.
2. The ſame with the long ſides of the common rectangular baſe replaced by two hexagonal planes.
3. The ſame as var. 2, with the edges of the pyramids adjacent to the common baſe replaced by ſecondary four-ſided planes.
4. A very ſhort eight-ſided priſm terminated by ſummits of eight planes placed upon the correſponding ſides of the priſm.

Externally the cryſtals are ſmooth and ſhining; internally they are ſplendent with a vitreous luſtre. The fracture of this mineral is compact. It is more or leſs tranſparent paſſing into tranſlucent. It is ſoft, ſomewhat brittle, and eaſily frangible. Sp. gr. 6.3.

Before the blowpipe it decrepitates on the firſt application of the flame, but when previouſly pulverized it melts into a brilliant ſcoria, which by continued ignition on the charcoal is reduced to metallic lead. It has been analyzed by Klaproth with the following reſults.

From Angleſey.	From Wanloch-head.	
71.	70.5	Oxyd of lead
24.8	25.75	Sulphuric acid
2.	2.25	Water
1.0	0.	Oxyd of iron
98.8	98.5	

It occurs in veins of galena at Wanloch-head, and in the province of Andaluſia in Spain, and in a bed of cellular quartz with iron pyrites and iron ochre at Parys mine in Angleſey.

Sp. 10. Arſeniat of Lead.

Of this there are two ſubſpecies.

1. *Subſp.* Reniform Arſeniat. *Bleiniere*, Karſten.

The colour of the recent fracture is browniſh-red, but by expoſure to the air it paſſes into ochre and ſtraw-yellow. It occurs in reniform maſſes, the ſurface of which is rough and uneven. Internally it is gliſtening with a reſinous luſtre. Its fracture is conchoidal. It occurs in coarſe-granular diſtinct concretions; is opake; gives a dull orange-yellow ſtreak; is ſoft and brittle. Sp. gr. 3.92.

Before the blowpipe it melts, emits an arſenical odour, and at length is converted into a black ſhining globule, in which grains of lead are obſervable.

According to an analyſis by Bindheim it conſiſts of

35.	Oxyd of lead
25.	Arſenic acid
1.5	Silver
14.	Iron
7.	Silex
3.	Alumine
10.	Water
95.5	

It has hitherto been found only at Nertſchinſk in Siberia.

2. *Subſp.* Green Arſeniat of Lead.

Its colour varies from meadow-green to wax-yellow. It occurs in needles, in fine filaments, in compact maſſes, and granular concretions.

Its luſtre varies from ſilky to reſinous. It is tranſlucent, moderately brittle, and eaſily frangible. Sp. gr. 5.04.

Before the blowpipe it gives out an arſenical vapour, and is reduced to a metallic globule.

It occurs in veins with galena in Andaluſia in Spain, and in the department of the Saone and Loire in France.

The arſenico-phoſphat of lead of Hauy may probably alſo be referred hither. Its colour is yellowiſh-green; it occurs in mamillary maſſes, ſtudded with brilliant points. Before the blowpipe it gives out an arſenical odour. It contains, according to Fourcroy, by whom it has been analyſed,

50	Oxyd of lead
29	Arſenic acid
14	Phoſphoric acid
4	Oxyd of iron
3	Water
100	

It is met with in a mine at Roſiers in Auvergne.

Sp. 11. Molybdat of Lead. See MOLYBDENA.

Sp. 12. Chromat of Lead. See CHROME.

Sp. 13. Lead Ochre. *Bleyerde*, Wern. *Plomb terreux*, Broch.

Of theſe there are two ſubſpecies.

1. *Subſp.* Indurated.

Its colour is yellowiſh or greeniſh-grey, ſtraw-yellow, apple-green, ſmoke-grey, and light browniſh-red. It occurs in maſs. Internally it is glimmering or gliſtening, with a reſinous luſtre. Its fracture is fine-grained uneven, paſſing into fine ſplintery and earthy, alſo into flat conchoidal. It is opake or at moſt ſlightly tranſlucent on the edges. It gives a browniſh ſtreak; is ſoft, paſſing into friable; is not very brittle, but is eaſily frangible.

It is reducible before the blowpipe, efferveſces with acids, and is blackened by hydroſulphuret of ammonia.

It occurs with the other ores of lead, and is uſually accompanied by iron pyrites and malachite.

2. *Subſp.* Friable.

Its colour is yellowiſh-grey approaching to ſulphur-yellow. It occurs maſſive, diſſeminated, and ſuperficial. It is compoſed of dull, duſty, friable particles; is meagre and rough to the touch, and is heavy.

It is found to accompany galena and the other ores of lead, and is found at Wanlochhead and the Lead-hills in Scotland, in the Hartz and Saxony, in Poland, and Siberia.

§ 2. *Smelting and Reduction of Lead Ore.*

The only ore of lead that is wrought in the large way is galena, and the method of treating this is very ſimple, partly on account of the richneſs of the ore and partly on account of the low price of the metal itſelf, which therefore will not admit of any but the moſt ſummary methods of bringing it into a marketable ſtate.

The ore when firſt brought up from the mine is *dreſſed* by women and boys, who with a hand-hammer ſeparate the greater part of the adhering impurities, conſiſting of blende, iron pyrites, quartz, calcareous ſpar, &c. The reſidue being broken into pieces about the ſize of a hazle-nut is waſhed from all adhering clay and dirt, and is then ready to be ſmelted. The furnace uſed for this purpoſe is the common reverberatory with a low arch. A ton or more of the ore is ſpread on the floor of the furnace, and by means of the flame from pitcoal it is quickly brought to a bright red heat. In this ſituation it is occaſionally ſtirred with iron rakes to expoſe freſh ſurfaces to the action of the flame and facilitate the ſeparation of the ſulphur. In a ſhort time the maſs begins to acquire a paſty conſiſtence; upon which the heat is lowered and the ore is kept at a dull red till the ſulphur is nearly all got rid of; the fire being then increaſed the ore is brought to a ſtate of perfect fuſion, and viſibly conſiſts of two fluids; the lower is the metallic lead, the upper is a vitreous ſlag, ſtill holding a conſiderable portion of lead but mixed with various impurities. In this ſtate of the proceſs the fire is damped and a few ſpadefuls of quicklime are thrown into the fluid maſs; by this the ſcoriæ are ſuddenly ſolidified, and are raked to the ſide of the furnace; the tap-hole is then opened, and the lead runs into moulds placed to receive it, where it congeals into oblong maſſes called *pigs*, weighing about 60 lbs each. As ſoon as the lead has run out of the furnace, the tap-hole is cloſed, the ſcoriæ are replaced in the bed, and being quickly raiſed to a glowing red heat are ſoon melted; the greateſt part of the lead that they contained by this means collects into a maſs at the bottom; a little lime is thrown in as before, the ſcoriæ thus rendered ſolid are raked aſide, and the lead which they covered is let off into a mould. This ſecond ſcoria, though ſtill holding from 5 to

8 per cent. of lead, is now removed from the furnace, and applied to no purpoſe but that of mending roads, the expence of ſeparating the laſt portions of metal being more than the value of the produce.

The lead of the firſt running is the beſt; that procured from the ſcoriæ being ſenſibly harder, and leſs malleable on account of the iron that it contains.

It is a matter of doubt among the moſt intelligent ſmelters whether there is any advantage in retaining the carbonat of lead, with which the galena is very often mixed in conſiderable proportion. On the one hand it is certain that it contains a large quantity of metal, and in aſſays is very eaſily reducible; but on the other hand, when treated in the reverberatory it vitrifies almoſt at the firſt impreſſion of the heat, and being a very active flux it is apt to bring the whole into fuſion while much ſulphur ſtill remains unſublimed; hence the amount of ſcoriæ is prodigiouſly increaſed, and with it the trouble of the ſmelters, while the produce of lead is very little augmented.

§ 3. *Aſſay and Analyſis of the Ores.*

The analyſis of the ores of lead is upon the whole extremely ſimple. In general the moiſt way is the moſt accurate.

Before giving the individual proceſſes the general methods may be mentioned whereby lead is ſeparated from the other metals with which it is uſually combined in the different ores, and the data on which it may be eſtimated in analyſis.

Lead is readily ſeparated from ſilver by making a ſolution of both in nitric acid, and adding muriatic acid as long as any precipitate appears.

The ſilver falls down in the form of luna cornea, and with it a quantity of muriat of lead, and if the mixture ſtands ſome hours undiſturbed, this latter ſalt alſo forms needled cryſtals on the ſurface of the luna cornea. All the ſilver falls down in this manner, but part only of the lead, and the muriat of lead is ſeparated from the luna cornea by boiling water, 22 parts of which will diſſolve 1 of muriat of lead, but not a particle of the muriat of ſilver. The ſolution of the muriat of lead is ſtill more eaſily effected by digeſting in dilute nitric acid, which diſſolves it readily, but not the luna cornea.

Lead is ſeparated from biſmuth by diſſolving both to ſaturation in nitric acid, either concentrated, or diluted with no more than a fourth of water, and then pouring the concentrated ſolution into a large quantity of water. The oxyd of biſmuth then ſeparates as a heavy white powder, and the lead remains diſſolved. Some biſmuth however remains, but to the ſolution may then be added a ſaturated ſolution of ſulphat of ſoda, which will precipitate the lead only in the form of a white pulverulent ſulphat of lead, the compoſition of which will be preſently mentioned. But where all the biſmuth is to be obtained for the purpoſe of analyſis, and not merely to be ſeparated from the lead, it is better after the biſmuth has firſt pecipitated, to add muriatic acid to the clear ſolution, which will throw down the ſilver, if there be any, and alſo ſome muriat of lead, mixed with ſome of the biſmuth that remains in the ſolution, and which laſt if rediſſolved in nitric acid, will again be decompoſed by water as before. The whole muriat of lead may then be diſſolved in water and nitric acid, and converted into a ſulphat by means of ſulphat of ſoda as before.

Lead is ſeparated alſo from iron and copper by diſſolving both in nitric or muriatic acid, and adding ſulphat of ſoda to precipitate the lead. If the nitric acid be uſed, ſome of the oxyd of iron will firſt precipitate as a brown red ochre, which ſhould be removed.

The ſame method will ſeparate lead from tin, cobalt, and zinc.

The compoſition of the ſulphat of lead artificially formed in theſe proceſſes, has been given with ſome ſmall variation by different chemiſts; Klaproth eſtimates it as follows.

100 parts of ſulphat of lead, *dried at a low red heat*, are compoſed of 73.96 of oxyd of lead and 26.04 of ſulphuric acid, and the above oxyd of lead is compoſed of 69.44 of metallic lead, and 4.52 of oxygen. This is not the only ſtate of oxygenation of which lead is capable, but it is that in which, according to Klaproth, it is inferred to exiſt in all the native ſalts and oxyds of this metal hitherto analyſed.

It muſt be obſerved however, that this calculation gives a much lower ſtate of oxygenation than is found by other experiments, as will be noticed preſently, and the eſtimation of the quantity of metallic lead is made by other chemiſts, and even in other experiments of Profeſſor Klaproth, to riſe as high as about 71 per cent. Mr. Hatchett reckons it to be 70.9.

But where the muriat of lead is free from other admixture, the quantity of metal may be eſtimated without converting it into a ſulphat, by the following data: 100 parts of lead diſſolved in nitric acid, and decompoſed by dropping in muriatic acid as long as any turbidneſs enſued, and evaporated to perfect dryneſs (but ſhort of volatilization of any part of the combined muriatic acid) produced 133 of muriat of lead, and conſequently 100 parts of dry muriat of lead indicate 75.2, nearly, of metallic lead, and (if oxygenated in the ſame degree as in the ſulphat) 4.89 of oxygen, or 80.09 of oxyd of lead.

The muriat of lead may alſo be reduced by diſſolving it in water and immerſing a rod of iron, whereby the lead will be precipitated in the metallic ſtate in fine lamellæ.

Some of the analyſes of the individual lead ores may now be mentioned.

Vauquelin analyſed a galena from Cologne in the following way.[a]

A quantity was roaſted ſlowly and loſt 12 per cent. of ſulphur in the proceſs. Another quantity was heated with very dilute nitric acid, which gave a ſmell of ſulphuretted hydrogen, and diſſolved all the metallic part. The undiſſolved reſidue heated to redneſs, parted with its ſulphur, and 16.67 per cent. of ſilex was left. The nitric ſolution was then decompoſed by ſulphat of ſoda, and the ſulphat of lead collected and weighed. The proportion of metal it contained (eſtimating 100 of the ſulphat to be equivalent to 75.72 of metal) was 63.1 per cent. The liquor was then ſaturated with ammonia, which depoſited 3.3 of oxyd of iron, and laſtly carbonat of potaſh threw down 3 of carbonat of lime.

In the dry way the galena after roaſting may be mixed with thrice its weight of black flux, covered with ſalt, and melted, when a button of reduced lead will be found at the bottom, which will alſo contain the ſilver and other metals, if preſent.

The triple ſulphuret of lead, antimony, and copper found in Cornwall, was thus analyſed by Mr. Hatchett.

Two hundred grains were put into a matraſs with 2 ounces of muriatic acid, and heated, and nitric acid was added drop by drop, till the whole moderately efferveſced. It was then gently heated for an hour, and a green ſolution was formed, on which floated a quantity of ſulphur, which was collected, digeſted ſeparately with a little muriatic acid, and then waſhed and dried. It weighed 34 grains, and afterwards burned away in a red hot earthen cup, without reſidue, and therefore was pure. The ſolution, with the muriatic acid in which the ſulphur had been waſhed, was boiled, and then mixed with 6 pints of boiling diſtilled water, which it rendered inſtantly milky, and was filtered while hot, and the filter waſhed with more boiling water. The white precipitate left on the filter, when dried on a ſand bath, weighed 63 grains, and was oxyd of antimony. The liquor with the waſhings depoſited on cooling ſome cryſtallized muriat of lead. It was evaporated nearly to dryneſs, and a few drops of ſulphuric acid added to the liquor left, to ſeparate in the form of a ſulphat, what little of the lead remained in ſolution. The reſidue was then rediſſolved in boiling water, and decompoſed entirely by ſulphat of ſoda, and the ſulphat of lead thus produced, (added to the former portion) was waſhed and dried on a ſand bath, and weighed 120.2 grains.

The liquor which was now blueiſh-green, was rendered of a deep blue by ammonia, and a ſmall quantity of oxyd of iron ſeparated, which when dried and heated with wax, became magnetic, and weighed 2.4 grains.

The liquor was then evaporated nearly to dryneſs, boiled with a ſtrong lixivium of potaſh till nearly dry, and on waſhing with water, ſome black oxyd of copper was left weighing 32 grains after thorough drying.

In the above analyſis the metals are eſtimated as in their metallic ſtate, this being the ſtate in which they exiſt in the ſulphurets, and hence, for the 63 grs. of oxyd of antimony, 48.46 of the regulus are to be put down, and for the 120.2 of ſulphat of lead, the author eſtimates 85.24 of metallic lead, which is in the proportion of 70.9 in 100.

The carbonat of lead was analyſed by Klaproth in the following way: 100 grains were diſſolved in a mixture of 200 grains of nitric acid with 300 of water, and the loſs of weight by the efferveſcence noted, which amounted to 16 grs. and was carbonic acid. The nitric ſolution was then diluted, and a cylinder of zinc immerſed, which precipitated the lead in the metallic ſtate in beautiful vegetations. This waſhed and dried, weighed 77 grains, equivalent to 82 of oxyd, as it is in this ſtate that the lead exiſts in the ore. This proportion however, would give an increaſe of only 6.5 of oxygen upon 100 of lead.

That rare variety of lead ore, the compound carbonat and muriat of lead, has been analyſed both by Klaproth and Chenevix. By Klaproth, the following method was purſued: fifty grains of the ore were rubbed with 150 of very pure carbonat of potaſh, (previouſly freed from every muriat) and heated in a platina crucible to a moderate redneſs, then lixiviated and filtered. An oxyd of lead was left behind. The ſolution was ſlightly ſuperſaturated with nitric acid and precipitated with nitrat of ſilver. The muriat of ſilver thus obtained weighed 27 grains, equal to more than 4 of concrete muriatic acid. Another quantity of the ore of 100 grains was then powdered and nitric acid affuſed, which produced an efferveſcence of carbonic acid. This ſolution gave with nitrated ſilver 55 grains of luna cornea, correſponding very cloſely in proportion with the former experiment, the acid of which amounted to 8.5 grains. The lead was then precipitated by *cauſtic* potaſh and the oxyd thus procured weighed, after thorough drying, 85½ grains, which is the ſtate of oxygenation in which it is ſuppoſed to exiſt in the ore. In this caſe, therefore, 85.5 grains of oxyd of lead were combined with only 8.5 of muriatic acid which is far ſhort of the ſaturating quantity, ſince in the artificial cryſtallized muriat of lead the proportion of acid amounts to 13 or 14 per cent. This deficient ſaturation therefore allows the preſence of carbonic acid, which amounts to 6 grains, and completes the ſaturation of oxyd.

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[a] Journ. des Mines, No. 68.

[b] Eſſays Vol. 2.

A ſimilar ore was analyzed by Mr. Chenevix,* nearly in the ſame way and with the ſame reſult. The ore was firſt diſſolved in nitric acid, and the quantity of carbonic acid, amounting to 6 grains, eſtimated by the loſs after efferveſcence. The ſolution was then neutralized by ammonia, and tried by different teſts. As nitrat of lime gave no precipitate, the ſolution could not contain either the arſenic or molybdic or phoſphoric acids, and as nitrat of barytes gave none, the abſence of ſulphuric acid was proved.

Nitrat of ſilver was then added and a copious precipitate enſued, and the luna cornea weighed after drying 48 grains, which Mr. C. eſtimates as equivalent to 8 of muriatic acid. The compoſition of the ore is thus ſtated: 6 grains of carbonic acid ſaturate 34 of oxyd of lead, and 8 of muriatic acid ſaturate 51 of oxyd of lead, and the acids may be ſuppoſed to be in the ſtate of perfect ſaturation, conſequently the ore is compoſed of 59 muriat of lead and 40 of carbonat of lead; or of 14 of acid and 85 of oxyd.

The Angleſea ſulphat of lead was thus analyzed by Klaproth: 100 grains were firſt ignited moderately and loſt 2 grains, which were water of cryſtallization. The remainder was mixed with 400 grains of carbonated potaſh, and kept for ſome time in a red heat in a platina crucible, which gave a reddiſh-yellow hardened maſs. This, digeſted with water, was all diſſolved except the oxyd of lead ſeparated in the previous proceſs, amounting to 72 grains, after ſtrong drying. This oxyd was rediſſolved in nitric acid, and depoſited thereby one grain of oxyd of iron. The ſolution was then decompoſed by zinc, and yielded 66.5 grains of metallic lead. The alkaline fluid formed by the waſhing of the contents of the crucible, after ignition, was then ſaturated with nitric acid and acetate of barytes added as long any ſulphat of barytes was precipitated. This amounted to 73 grains, equal to 24.8 of concrete ſulphuric acid on the eſtimation that 100 parts (after ignition) contain 34 of acid. The iron in this ore appears merely caſual.

The phoſphated lead ores have been alſo examined by the ſame eminent chemiſt with much attention. The compoſition of all the varieties is very uniform, all conſiſting of phoſphoric acid and oxyd of lead, together with muriatic acid, the quantity of which varies very little. It is a diſtinguiſhing and ſingular property of the phoſphat of lead, that when melted into a round bubble under the blow-pipe it aſſumes a regular polygonal garnet-ſhaped form on the moment of ſolidifying by cooling.

The green phoſphat was thus analyzed: after ſome imperfect attempts at reduction in the dry way, 100 grains of the ore were diſſolved in hot nitric acid leaving no reſidue. Nitrat of ſilver then gave a precipitate of 11 grains of luna cornea, the muriatic acid of which amounted to 1.7 grains. Sulphuric acid was then added to the warmed ſolution, by which ſulphat of lead was precipitated, weighing after ignition 106 grains, equal to 73.61 of metallic lead or 78.4 of the oxyd. The liquor was then freed from the exceſs of ſulphuric acid by nitrat of barytes, it was then nearly ſaturated with ammonia, and acetite of lead added. The phoſphoric acid in the ſolution was then precipitated in the form of phoſphat of lead, weighing, after ignition, 82 grains, of which the mere acid amounts to 18.37 grains. The reſt of the ſolution was then mixed with a little muriatic acid, inſpiſſated by evaporation, and alcohol added to rediſſolve the muriat of iron then formed, if any, from which by the addition of pruſſiat of potaſh there was obtained an extremely ſmall blue precipitate, indicating no more than about .1 of a grain of oxyd of iron.

In another experiment the phoſphoric acid, inſtead of being engaged with lead, was ſaturated partly by ſoda, partly by ammonia, and by due evaporation and cooling, cryſtals of the microcoſmic ſalt, or the phoſphat of ſoda and ammonia were obtained. The other varieties of this phoſphat were analyzed in the ſame way.

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* Phil. Journ. 4to. vol. iv.

With regard to the analyſis of the molybdat of lead the reader is referred to the article *Molybdena*, and to *Chrome*, for the Chromat of lead. Thoſe ores in which lead is only a ſmall part of the metallic contents will be deſcribed under the other metals as ſilver, biſmuth, &c.

The compound of oxyd of arſenic, lead, and iron, examined by Lelievre and Vauquelin[b], gave the following appearances: 100 parts roaſted for half an hour, with a little ſuet added occaſionally to favour the evaporation of the arſenic, loſt 38, and became black and magnetical. The remaining 62 parts boiled in muriatic acid made a red ſolution, giving out much oxymuriatic acid gas, and cryſtallized muriat of lead was depoſited. This ſolution evaporated, rediſſolved in water, and decompoſed by ſulphat of ſoda, gave 25 of ſulphat of lead, equal to 20.2 of lead or 22 of the oxyd. The reſidue, ſaturated with ammonia, gave 39 parts of oxyd of iron.

The analyſis of lead ores in the dry way is attended with much more loſs of the metallic contents, eſpecially when alkaline fluxes are uſed, all of which act more or leſs on this oxyd.

LEAD is a metal of a blueiſh-white colour, almoſt ſilver-white when recently melted, but very ſoon tarniſhes. It gives a peculiar ſmell when rubbed or heated. Its ſpecific gravity, according to Briſſon, is 11,352. It is very malleable, readily extending under the hammer into very thin leaves, but its tenacity is leſs than that of any other metal, for a wire $\frac{1}{10}$ of an inch in diameter will break with a weight of 30 lbs.

Lead is the leaſt ſonorous of all the metals, giving when ſtruck a very flat heavy ſound. It melts long before being red-hot. The melting point of this metal has been variouſly given, owing to the known irregularity of the mercurial thermometers at very high temperatures.

Morveau gives it at 590° Fahr. According to Mr. Crichton it is 612°. When ſlowly cooled it cryſtallizes in quadrangular pyramids. Heated fully to redneſs it ſmokes and ſublimes in the open air, giving a grey oxyd, which ſettles on the ſides of the veſſel that contains it, or if in large quantity mixes with the atmoſphere around and collects in the chimnies of the furnaces where it is melted. Lead in all forms and combinations is poiſonous when taken in any quantity, and a frequent expoſure to its vapour, or much handling it, gradually produces dangerous bowel-complaints, paralytic ſymptoms, and other maladies.

Though the ſurface of lead at a common temperature ſoon tarniſhes, this metal will remain expoſed to air and all weathers for a great length of time without further change, the oxidated ſurface protecting the inner part from deſtruction, and hence the durability of leaden roofs, pipes, &c. but yet in proceſs of time the whole is corroded throughout.

Water has but little direct action on this metal either hot or cold, not being decompoſed by it as it is by iron and ſome other metals; but it ſlowly aſſiſts the action of the air, for lead will be corroded ſooner in a damp than in a dry atmoſphere.

When lead is melted in free expoſure to the air, it becomes almoſt immediately covered with a wrinkled pellicle of a dirty grey colour, and if this is ſkimmed off others form in ſucceſſion, till the whole metal is changed into a yellowiſh-grey oxyd, the weight of which was one of the earlieſt obſervations made on the effect of calcination in increaſing the weight of metals.

This grey oxyd, by a further continuance of heat with conſtant ſtirring, paſſes through various ſhades of a greeniſh-yellow to a deep dun-yellow, owing to a ſucceſſive abſorption of oxygen. The higheſt ſtate of oxygenation to be produced by mere calcination, appears to be that in which the oxyd has a beautiful high red colour, with more or leſs ſcarlet, when it is called *Minium* or *Red Lead*, a ſubſtance well known as a pigment, and eſpecially as a flux in glaſs-making, for which it is largely employed.

Minium, however, cannot be made with any certainty in the ſmall way by mere calcination in the air, however long this is continued, the colour of the oxyd never riſing higher than a dun yellow; it is only produced in manufactories in the large way, with frequent ſtirring. The proceſs for making red lead is thus deſcribed by Dr. Watſon[c] as carried on in Derbyſhire.

The furnace is very much like a baker's oven with a low vaulted roof, and on each ſide of the furnace are two party-walls riſing from the floor of the ſurface but not reaching to the roof. In the interval between theſe walls and the ſides of the furnace the coal is burned and the flame draws over the top of the party-walls, and ſtriking the roof is thence reflected down upon the ſurface of a quantity of lead which is laid on the floor of the furnace. The metal ſoon melts, and inſtantly becomes covered with a pellicle which is ſucceſſively raked off till the whole is changed into a greeniſh-yellow powder. This is taken out, ground in a mill, and waſhed, to ſeparate the portion of lead that ſtill remains in the metallic ſtate, by which it becomes an uniform yellow colour, and is then thrown back into the furnace and conſtantly ſtirred, ſo that every part may be equally expoſed to the action of the flame, and in about forty-eight hours of calcination it is converted into *red-lead*.

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[b] Phil. Mag. vol xvi.

[c] Eſſays, vol. iii.

Some practical nicety is required in the management of the fire, which if too ſlack gives only a yellow or orange coloured powder, and if too fierce makes the minium duſky and deſtroys that brilliant gloſs for which it is ſo much admired. There are beſides other minuter circumſtances of management, and probably kept ſecret as much as poſſible. Jars[d] mentions in particular that of cooling the minium when made very gradually, and cloſing all the openings of the furnace, otherwiſe the beauty of colour is much impaired. Some makers alſo ſprinkle the ſurface with water occaſionally during the calcination.

In Holywell minium is made from litharge, which ſaves the previous calcination.

A portion of the lead in the proceſs of converſion into minium is always loſt by volatilization, part of it being diſſipated in the air and another part ſettling in the chimnies and on the roofs of the furnace, in the form of a yellowiſh-white ſoot, with cryſtallized lumps intermixed, which is collected from time to time, and either reduced into lead or is mixed with the lead in the ſubſequent calcination. The quantity of this ſublimate collected, according to Watſon, is about $\frac{1}{400}$ of that of the minium produced, but of courſe muſt vary greatly. On this account, and from the loſs by entire volatilization in the air, it is impoſſible to aſcertain directly the full increaſe of weight which the lead ſhould acquire by converſion into minium. The actual increaſe is on an average about a tenth, twenty hundred weight of lead producing twenty-two hundred of minium.

It has been mentioned that the oxyd of lead becomes yellow before it turns red. The ſubſtance called *Maſſicot*, and uſed as a yellow pigment is generally made of this yellow oxyd, but the finer ſorts are ſaid to have an addition of muriat of ammonia, and to be therefore a muriated oxyd of lead, or approaching to that fine pigment called the Naples yellow, which will be afterwards noticed.

Litharge is another of the oxyds of lead made by the ſimple action of heat and air. It is produced in the proceſs of extracting the Silver from lead, as will be more fully deſcribed under that article. The ſilver-holding lead is put in a large ſhallow diſh made of aſhes, and therefore very porous, and is kept till red-hot in a wind-furnace, at the back of which enters the pipe of large bellows that direct a blaſt of air on the ſurface of the red-hot metal. This converts it into a ſcaly yellowiſh-white gliſtening oxyd, which is raked off ſucceſſively to expoſe new ſurfaces, till nearly the whole of the lead is thus changed into litharge. There are ſlight variations in the colour of litharge, ſome kinds having more of a ſilvery gloſs, others being of a dull red-yellow. Part of it is again reduced into very pure and ſoft lead, and the reſt is ſelected for ſale. The waſte of lead by volatilization is many times more in reducing lead into litharge than into minium, ſo that, though there is a large gain of oxygen from the air, the litharge weighs leſs than the lead from which it was produced. Part of it, however, is loſt by ſoaking into the teſt, a porous veſſel in which it is made.

All the oxyds of lead, when ſtrongly heated to a full redneſs, very readily run into a glaſs which has a clear topaz-yellow colour, and is the moſt powerful flux known of every vitrifiable matter, ſo that, in a very ſhort time, the vitrified oxyd corrodes all the common crucibles and runs through them like a ſieve, and even the cloſeſt porcelain can only retain it for a time. Minium in vitrification always gives out a quantity of oxygen gas, but the quantity varies much, even in the ſame ſample, and is never ſo much as 8 per cent. During the vitrification a portion of the minium is ſpontaneouſly reduced to the metallic ſtate, and is found at the bottom of the crucible. A fuller account of the vitrifying power of the oxyds of lead will be found under the article *Glaſs*.

The above oxyds of lead, namely maſſicot, minium, and litharge, do not appear to have been accurately analyzed with a view to aſcertain their metallic contents in the dry way by ſimple reduction, but the following examination of them, and the other ſalts and oxyds of lead, by Dr. Thomſon, in the moiſt way, will give ſome information concerning their compoſition.[e]

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[d] Voyage Metall.

Minium loſes no ſenſible weight at a heat of 400°. In ſeveral experiments to aſcertain the loſs by fuſion, no agreeing reſult could be obtained, the loſs varying from 4½ to 7 per cent. The common minium of the ſhops always contains ſome impurities, generally ſand, and alſo an alloy of antimony, and a minute portion of ſilver.

When red lead is digeſted in nitric acid a part is diſſolved and the reſt is converted into a brown powder that remains at the bottom of the veſſel. The lead in ſolution is found by other experiments (to be preſently mentioned) to be in the ſtate of oxygenation in which the oxygen forms 9.5 per cent. or as the *yellow* oxyd; whilſt the inſoluble reſidue is ſuperoxygenated in the proportion of 20 per cent. a ſeparation of an uniform ſubſtance into two others with oppoſite characters, being by no means uncommon in chemical phenomena. By eſtimating the total of oxygen in the more and the leſs oxygenated portion, Dr. T. concludes, that minium is compoſed of about 88 of lead to 12 of oxygen.

Litharge analyzed by the ſame chemiſt loſt at a red heat about 4 per cent. of its weight. It diſſolves in nitric acid *with effervеſcence*, and conſequent loſs of 4 per cent. of weight, which may be reckoned to be carbonic acid. By precipitating the ſolution with a carbonated alkali and other experiments, Dr. T. ſtates the compoſition of litharge to be about

$$\begin{array}{rl} \left.\begin{array}{r}86.9\ \text{lead}\\ 9.1\ \text{oxygen}\end{array}\right\} & 96\ \text{yellow oxyd}\\ & 4\ \text{carbonic acid}\\ \hline & 100.\end{array}$$

According to the above analyſis therefore minium is more highly oxygenated than litharge, but the latter contains a quantity of carbonic acid, which minium does not. It is ſingular, however, how this difference with reſpect to carbonic acid ariſes, ſince the heat at which each oxyd is made does not appear to differ materially, and certainly, of the two, minium is that which is much more directly expoſed to the action of carbonic vapour, owing to the reverberation of the coal flame on its ſurface, during ſo many hours in the manufacture.

It has been mentioned that lead, when kept in fuſion expoſed to the air, firſt becomes changed to a duſky-grey powder with a greeniſh tinge. This has been conſidered by ſome chemiſts as lead in the firſt ſtate of oxygenation, but Profeſſor Prouſt has properly obſerved,[f] that it is only a mixture of the yellow oxyd with particles of metallic lead, whence the green colour from the mixture of the yellow of the former with the blue of the latter. This opinion is confirmed by the fact, that in the firſt part of the proceſs of making red-lead the duſky-green powder is ſeparated by mere waſhing, into *yellow* oxyd and the blue-black particles of metallic lead, the latter ſubſiding ſooneſt in the water. The *yellow* oxyd therefore appears as far as hitherto known to be in reality the firſt ſtate to which lead is reduced by calcination in the air.

But Profeſſor Prouſt aſſerts that an oxyd with a leſs proportion of oxygen (and at the minimum of oxydation) may be formed by boiling the nitrat of lead on metallic lead, whereby the oxygen of the nitrat is compelled to diſtribute itſelf equally over a much greater quantity of lead, and the acid forms with this new oxyd a brilliant yellow ſcaly ſalt, very ſoluble, but the proportions of which have not yet been determined. On this ſubject Dr. Thomſon has the following experiments: 100 grains of nitrat of lead were diſſolved in water and boiled with a cylinder of clean bright lead. The metal ſoon loſt its brilliancy, became covered with a white cruſt, and the liquid became yellow. When all action appeared to have ceaſed, the cylinder was taken out, and was found to have loſt 44 grains. But the whole of this was not diſſolved, for a *bluiſh-grey powder* began to collect during the boiling, and increaſed as long as the cylinder of lead continued to be acted on. As the ſolution cooled it depoſited the yellow ſcaly cryſtals mentioned by Prouſt, which ſalt has the following properties: the taſte is ſweet and aſtringent, like the common nitrat, but it is leſs ſoluble in water; when cautiouſly heated to redneſs it melts into a yellow maſs, loſing thereby 18.5 per cent. of its weight, which are acid and water of cryſtallization, and 81.5 of a *yellow oxyd* remains. This oxyd rediſſolved in nitric acid, and cryſtallized yields 117. of common nitrat of lead. But 117 of common nitrat are found by ſeparate experiments to contain about 81.5 of yellow oxyd, and hence it would appear that this ſalt is not a nitrated *ſub-oxyd* of lead but a *ſub-nitrat* of lead, or in other words the degree of oxygenation of the lead is the ſame in both, but the difference conſiſts in the relative proportion of nitric acid. A ſimilar proof of this was alſo deduced from the decompoſition of this yellow ſalt by carbonat of potaſh, both in the moiſt and the dry way, and a ſub-nitrat extremely ſimilar was formed ſimply by heating the common nitrat to expel only part of its acid, as will be preſently noticed. It does not appear however that Dr. T. examined the *blueiſh-grey powder* produced by boiling lead with nitrat of lead, which therefore deſerves a further examination.

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[e] Phil. Journ. 8vo. vol. viii.

[f] Journ. de Phyſ. tom. lvi. p. 206.

The *yellow oxyd* of lead is that which appears to be the baſis of by far the greater number of the ſalts of this metal, and therefore is of primary importance. It is formed in the calcination of this metal *per ſe*, and is formed at ſo early a period that it is probably the firſt change that this metal undergoes by union with oxygen, though, as already mentioned, the colour is not obvious at firſt, on account of being mixed with metallic lead finely attenuated, and not yet oxygenated, which debaſes the colour to grey or yellowiſh-green, till it is ſeparated by waſhing. *Maſſicot* is the yellow oxyd, as pure as it can be formed by mere calcination, but as this is changed to *minium* by continuing the proceſs, the yellow oxyd made by heat can never be procured ſo uniform as by ſolution.

If lead be diſſolved in nitric acid, the ſolution cryſtallized, the cryſtals diſſolved in water, and precipitated by carbonat of potaſh, a white carbonat of lead is produced, which heated in a retort gradually to redneſs, parts with its carbonic acid and water, and the pure yellow oxyd is left.

The proportions of theſe ſubſtances given by Dr. Thomſon are the following: 69 grains of lead form 112 of the ſolid nitrat (dried at 300°) which produce 90 of the carbonat, which is reduced by ignition in a retort to 77 of the yellow oxyd. Therefore 77 of this oxyd contain 69 of lead and 8 of oxygen, or per cent. 89.7 of lead and 10.3 of oxygen. But Prouſt gives the compoſition of the yellow oxyd to be 91 of lead and 9 of oxygen.

But Klaproth found that 100 parts of lead diſſolved in dilute muriatic acid,[g] precipitated by cauſtic potaſh, and the oxyd waſhed and briſkly dried till it began to turn yellowiſh, amounted to 115 grains, which would give the proportions of 86.78 of lead to 13.22 of oxygen. It is impoſſible to reconcile theſe reſults in a ſatisfactory manner without further experiments.

The yellow oxyd may alſo be obtained by direct calcination of the nitrat in cloſe veſſels till every thing volatile is driven off, by which the remaining oxyd melts into a hard yellow opake glaſs,[h] but this mode will not give the proportions with accuracy, as ſome of the lead is totally reduced in the proceſs, and is found diffuſed in globules in the ſubſtance of the glaſs.

There is yet another oxyd of lead to be noticed, which is the *brown oxyd*.

In this the lead is at the higheſt ſtate of oxygenation. It was firſt diſcovered by Scheele, and many of its diſtinguiſhing properties noticed by him. It is procured by adding nitric acid to minium. The experiments of Scheele are the following:[i]

If finely powdered minium be diſſolved in nitrous acid, diluted with a triple quantity of water, a black or brown powder remains which is the oxyd in queſtion. This is not ſoluble in the acid by itſelf, but on adding a little ſugar a clear ſolution is immediately obtained. The ſame happens with dilute vitriolic acid. If muriatic acid be poured on the black powder an effervescence takes place when warmed, and a ſtrong ſmell of aqua regia (oxymuriatic acid) riſes, the powder becomes white, and is turned into common white muriat of lead. If the oxyd be diſtilled by itſelf in a glaſs retort, it grows yellow and becomes in every reſpect ſimilar to the common yellow oxyd of lead, and is then entirely ſoluble in nitrous acid, and no longer gives any ſmell of oxymuriatic acid.

To theſe accurate obſervations of this excellent chemiſt it may be added, that in calcination *per ſe* it gives off much oxygen gas during its converſion to the yellow oxyd, which Dr. Thomſon eſtimates at 9 per cent. of the weight. In inſolubility in nitric acid it reſembles the black oxyd of mangaueſe, in which alſo ſugar effects a ſolution by depriving the oxyd of a portion of its oxygen. The ſame effect is produced by adding reguline lead to the acid and minium, by which alſo a ſolution is obtained,[k] and then none of the brown oxyd is formed, or if already formed it again diſappears. We may conclude therefore that minium is too much oxygenated to be entirely diſſolved without heat in nitric acid, but when theſe ſubſtances come in contact, an unequal partition of oxygen takes place, one portion abſorbing oxygen from the other, and becoming thereby the brown oxyd, and the other by the loſs of oxygen paſſing to the ſtate of yellow oxyd and diſſolving in the acid, and hence the nitrous ſolution ſtanding over the brown oxyd gives a yellow precipitate with alkalies, like the common nitrat of lead. The oxymuriatic acid gas paſſed through water and minium, alſo cauſes one portion to be diſſolved, and converts the other to the brown oxyd.[l]

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[g] Eſſays, vol. i. p. 539.

[h] Thomſon.

[i] Eſſays on Manganeſe.

[k] Chenevix.

This oxyd is a taſteleſs powder of a flea-brown colour, very fine and light.[m] As 100 grains loſe 9 of oxygen by heating, and become converted thereby into yellow oxyd, Dr. T. concludes that it is compoſed of 91 of yellow oxyd (containing 9.4 of oxygen) and 9 of oxygen, and hence 100 parts of it contain 81.6 of lead and 18.4 of oxygen. Profeſſor Prouſt makes the proportion of oxygen to be 21 per cent. Whichever calculation is taken it is unqueſtionably in the higheſt degree of oxygenation that lead is known to aſſume; minium, the next in order, containing not more than 12 per cent.

To the above obſervations on the oxyds of lead may be added in this place the compoſition of the artificial white carbonat produced by decompoſing any ſalt of lead by a carbonated alkali. According to Dr. Thomſon 112 grains of nitrat of lead (containing 69 of reguline lead) produce by ſolution in water, and decompoſition by carbonat of potaſh, 90 grains of the white carbonat when dried at 300°. Theſe 90 grains, when heated ſlowly to redneſs, part with 13 grains, which are water and carbonic acid, and 77 grains of yellow oxyd remain. Hence 100 grains of carbonat would produce 85.5 grains of yellow oxyd, the metallic part of which would be 76.6 grains, and the oxygen 8.9.

It may be of uſe to recapitulate all the oxyds and carbonated oxyds of lead in the ſuppoſed order of oxygenation, (beginning with the loweſt) with their leading properties, premiſing that it is a ſubject in which there are ſtill many points of uncertainty which it would not be very difficult for future experiments to clear up.

The ſub-oxyd ſtated by Prouſt to be formed by boiling the nitrat of lead with reguline lead. The exiſtence of this is doubtful.

The yellow oxyd preſumed to be the baſis of moſt of the ſalts of lead, particularly the common nitrat from which its proportions have been deduced. It is produced either by heating minium till it no longer gives out oxygen, or by calcining the ſolid nitrat (in both of which caſes it is mixed with reduced lead) or more accurately by heating the white carbonat nearly to melting, or by decompoſing the ſalts of which it is the baſis by cauſtic alkali. It gives *no* oxygen gas when heated even to melting. It contains, according to Prouſt, 9 per cent. of oxygen, and according to Thomſon about 10 per cent. It yet remains to be proved whether it does not acquire ſome other ingredient from the long-continued calcination with coal-flame beſides oxygen.

Maſſicot is the yellow oxyd formed by the calcination of lead in its progreſs to the ſtate of minium, and probably reſembles the yellow oxyd very cloſely, but is leſs uniform in its compoſition.

Minium or *red oxyd* is formed by long-continued calcination of lead, is inſoluble *as ſuch* in acids, apparently from being too highly oxygenated. Its compoſition is variouſly ſtated, and probably really varies according to the circumſtances of manufacture. Vauquelin ſtates it to contain generally no more than 9 per cent. of oxygen; Thomſon, 12 per cent. and others ſomewhat higher.

Though it gives out oxygen when heated, and paſſes to the yellow oxyd, this is not an unexceptionable proof of its containing more oxygen, on account of the entire reduction of a portion which always takes place, but the ſtrongeſt proof of its ſuper-oxygenation is derived from the action of nitric acid as already deſcribed, and its ſeparation into two oxyds, of which the *leaſt oxygenated* is the yellow oxyd, but if it is really the baſis of the ſulphat of lead it would appear to contain no more than about 7 per cent.

The brown oxyd is formed by the further oxygenation of minium, is inſoluble *as ſuch* in acids, with muriatic acid gives oxymuriatic acid gas, gives out much oxygen on being heated, and contains, according to Thomſon, 18.4 per cent. of oxygen, and according to Prouſt 21 per cent.

Litharge, according to Thomſon, is the yellow oxyd combined with about 4 per cent. of carbonic acid.

The white carbonat is the yellow oxyd fully ſaturated with carbonic acid and water, both of which are driven off at a red heat and the yellow oxyd left pure.

All the pure oxyds or carbonated oxyds of lead are reducible with great eaſe when heated red hot in contact with carbonaceous matter. It is not neceſſary to mix them with any reducing flux, nothing more being required in the way of experiment than to lay them in a covered crucible lined with charcoal. The ſame reduction takes place when heated by the blowpipe on charcoal.

When ſtrongly heated per ſe, and eſpecially in a draught of hot air, the oxyds of lead partly volatilize during vitrification.

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[l] Chenevix. Phil. Tranſ. for 1802.

[m] Thomſon.

§ 4. Lead is ſoluble in moſt acids. All the ſalts have a ſweetiſh taſte, and are ſtrongly ſtyptic or aſtringent in the mouth.

Pruſſiat of potaſh cauſes a white precipitate, and all the hydroſulphurets a deep black-brown precipitate, even in very minute quantities, ſo as to furniſh an excellent teſt for the preſence of this metal.

The ſulphuric acid has no action on lead when cold, or even when moderately warmed, whether concentrated or dilute, but at a boiling heat the acid, when ſtrong, diſſolves this metal ſlowly with evolution of ſulphureous acid, and a thick white paſty maſs is produced which is the ſulphat of lead. It is on account of the difficult ſolubility of lead in this acid that the chambers in which the ſulphuric acid is made are lined with ſheet lead, and the boilers in which it is firſt concentrated are of the ſame material, but a certain quantity of ſulphat gradually collects, which is thrown away.

The ſalt procured in this way has always an exceſs of acid by which it is rendered ſlightly ſoluble in water, but after it has been waſhed with water the remainder is nearly neutral, and is ſcarcely ſoluble in more water. The firſt waſhings will cryſtallize by evaporation into ſmall needles, which retain a ſmall exceſs of acid. Sulphat of lead is alſo formed by adding ſulphuric acid to any of the ſalts of the metal, ſuch as the nitrat or muriat, but the decompoſition is ſtill more perfect when any of the alkaline or earthy ſulphats is employed. In the former caſe ſome of the ſulphat remains in ſolution till the liquor is quite evaporated by favour of the exceſs of acid, in the latter the whole is precipitated at once. Thus a large quantity of this ſulphat is made in the preparation of the mordant of the bleachers by the decompoſition of alum and acetited lead, acetited alumine being contained in the clear liquor, and a copious depoſition of ſulphat of lead falling down. Sulphat of lead is ſcarcely decompoſable by mere heat, ſo that in all proceſſes of analyſis it may be dried freely at a moderate red heat without danger of error. On charcoal the metal is reduced. When very ſtrongly heated *per ſe* it gives ſulphureous acid gas.

The compoſition of this ſalt is given with but little variation by different chemiſts. The proportion of metal eſtimated by Kirwan is 71 per cent.[n] Klaproth (from the *artificial* ſulphat which is the kind here deſcribed) gives in one caſe 70.37, and in another 71 per cent. as obtained by the actual reduction of 100 parts of the ignited ſulphat; and Vauquelin makes it 70.4 per cent. All theſe eminent chemiſts alſo agree in fixing the quantity of oxygen united to theſe 70 or 71 of lead to be about 5 parts, which would form an oxyd in which the oxygen was no more than about 7 per cent. a proportion much leſs than that eſtimated to be contained in the yellow oxyd, which is ſuppoſed to be the baſis of this ſalt. With regard to the quantity of ſulphuric acid, 100 parts of the artificial ſulphat of lead, when decompoſed by acetited or nitrated barytes, give nearly 34 parts of ſulphat of barytes, of which the real ſulphuric acid is about 24, which therefore is the quantity contained in 100 parts of ſulphat of lead.

On a general average therefore it may be ſtated that 100 parts of this ſalt heated moderately to redneſs conſiſt of about 71 lead, 24 ſulphuric acid, and 5 oxygen.

The action of the *ſulphureous acid* on lead has been examined by Meſſrs. Fourcroy and Vauquelin.[o] This acid does not diſſolve reguline lead, but the oxyds readily if not too highly oxygenated. When ſulphureous acid is digeſted with minium the red colour is ſoon loſt, and with it the pungent ſmell of the acid, and a white magma is produced, which is a mixture of ſulphat and ſulphite of lead. But if this acid be added to the nitrat of lead, only the ſulphite of lead is produced, a collateral proof that in the nitrat the lead is leſs oxygenated than in minium.

This ſulphite when well waſhed is inſipid and inſoluble. Heated with the blowpipe on charcoal, it firſt becomes yellow, and gives a faint phoſphoreſcent flame, and then is entirely reduced. Heated gradually in a retort it gives out water, ſulphureous acid, and ſulphur, and at laſt a greeniſh-yellow ſulphat of lead is left. Sulphuric and muriatic acid added to this ſulphite make an efferveſcence and diſengage ſulphureous acid vapour, but the nitric acid changes it to the ſulphat.

The *nitric acid* a little dilute diſſolves lead with great ſteadineſs, giving out an uniform moderate ſtream of nitrous gas. If the acid be in too ſmall a quantity a white ſub-nitrated oxyd is formed, but more of the acid brings it to a clear ſolution, except a ſmall portion of a grey powder which Dr. Thomſon finds to be oxyd of antimony with a little ſilex.[p] This ſolution is not made cloudy by adding pure water by which it may be immediately diſtinguiſhed from the nitrat of biſmuth. By due evaporation it readily furniſhes large regular cryſtals, generally in the form of flattened trihedral pyramids with the apices truncated, but ſometimes in truncated hexahedral pyramids. Theſe cryſtals are of a pearl-white and ſoluble in about $7\frac{1}{2}$ parts of boiling water. A hundred parts of nitrat of lead, dried at 300°, contain 61.$\frac{2}{3}$ of lead.[q] This ſalt when in ſolution is readily decompoſed by ſulphuric acid or any alkaline ſulphat. Dry nitrat of lead, diſtilled *per ſe* in a full red heat, gives much nitrous gas, oxygen, and nitrous oxyd, and finally a yellow oxyd of lead remains which readily vitrifies and corrodes the ſides of the earthen or glaſs veſſel. But a portion is entirely reduced, ſo that globules of lead are found entangled in the vitrified oxyd. The loſs ſuſtained by nitrat of lead on being heated red-hot for half an hour amounts to about 40 per cent.[r]

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[n] Mineral Waters, Table 4.

[o] Syſteme de Conn. Chim. tom. 6.

[p] Phil. Journ. vol. viii.

Nitrat of lead, boiled with metallic lead, forms a ſalt much leſs ſoluble in water than the common nitrat, and appears under the form of yellow ſcaly cryſtals, as firſt noticed by Prouſt. Theſe, Dr. Thomſon has very ſatisfactorily ſhewn to be a *ſub-nitrat*, as already deſcribed when mentioning the oxyds of lead and the ſub-oxyd ſuppoſed by Prouſt to be formed in this way.

Nitric acid appears to be incapable of diſſolving minium without firſt decompoſing it, and cauſing it to ſeparate into two portions one of them containing more and the other leſs oxygen than minium. Hence when theſe two ſubſtances are digeſted together, about ſix ſevenths of the minium loſes oxygen enough to diſſolve and form the common nitrat, and the remaining ſeventh part paſſes to the ſtate of the inſoluble brown oxyd, as already mentioned when deſcribing the oxyds.

The yellow oxyd of lead diſſolves in nitric acid without efferveſcence of nitrous gas and the common nitrat is formed, and hence it is reaſonably inferred that the metal of this ſalt is in the ſtate of yellow oxyd, ſince the nitric acid is not decompoſed in this caſe. The pure alkali likewiſe ſeparates a yellow oxyd from the nitrat.

When *oxymuriatic* acid gas is paſſed through water with minium or any other oxyd of lead, it is readily abſorbed, the oxyd becomes of a deep black-brown and a part is diſſolved into a yellow liquor, the oxymuriat of lead, as firſt diſcovered by Prouſt. This ſalt is much more ſoluble than common muriat of lead. The ſame ſalt is formed by adding oxymuriatic acid to nitrat of lead, which does not produce an immediate white precipitate as the muriatic acid does, but gradually cauſes the depoſition of the brown oxyd, which as already mentioned is lead in the higheſt ſtate of oxygenation. An exceſs of the acid rediſſolves this oxyd.[s]

Potaſh or ſoda, added to this ſalt in ſolution, cauſes the precipitation of the brown oxyd, but ammonia immediately produces a white precipitate, which is probably muriat of lead formed by the diſoxygenation of part of the oxymuriatic acid by means of the ammonia.

Muriatic acid diſſolves lead when heated, but with difficulty. It combines readily with the yellow oxyd or the carbonated oxyd, expelling the carbonic acid of the latter.

But this muriat is more expeditiouſly formed by adding muriatic acid or any alkaline or earthy muriat to nitrat of lead, which cauſes immediately a white thick bulky precipitate, almoſt like a coagulum, and much more voluminous than that which is produced by adding the ſulphuric acid. This ſalt is ſweetiſh to the taſte, and is ſoluble in about 22 parts of cold water, in which latter reſpect, as well as in not changing colour by ſhort expoſure to light, it may be diſtinguiſhed from muriat of ſilver, which it reſembles in outward appearance; and water may therefore be uſed to ſeparate the muriat of lead from that of ſilver, but nitric acid is ſtill preferable. The muriat of lead is alſo ſoluble in acetic acid, by which alſo it may be diſtinguiſhed from muriat of ſilver, and from ſulphat of lead. When the hot ſaturated ſolution of this ſalt cools gradually, much of it ſeparates in ſmall feathery cryſtals, and the reſt in regular ſix-ſided priſms.

Muriat of lead is not deliqueſcent. When heated by itſelf it readily melts, and a white vapour ſublimes from the ſurface which leaves a very permanent ſugary taſte in the mouth. The melted ſalt has a ſemi-vitreous gloſſy appearance, and a grey-brown colour. It has been termed by the older chemiſts *plumbum corneum*, in analogy with the correſponding ſalt from ſilver the *luna cornea*.

The compoſition of this ſalt is given with ſome variation by different chemiſts. According to Klaproth, 100 grains dried fully, but ſhort of volatilization, contain 75 of lead and 14 of muriatic acid (the latter being eſtimated by being combined with ſilver and taking the acid of luna cornea at 15.4 per cent.) and the remaining 11 parts are oxygen and water. According to Chenevix 100 parts of muriat of lead decompoſed by nitrat of ſilver produce 81.3 of luna cornea, the acid of which is 12.5 parts. According to Kirwan 100 parts of muriat of lead fully deſiccated contain 17 of muriatic acid and 83 of oxyd of lead, which laſt (if oxygenated at the rate of 9 per cent.) would indicate 75.5 of lead; if at 7 per cent. 77 of lead.

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[q] Ditto.

[r] Ditto.

[s] Fourcroy Syſteme.

When muriatic acid is gently heated with minium the latter gives a part of its oxygen to the acid, part of which in conſequence aſſumes the form of oxymuriatic acid, and the lead, now partially deoxygenated, unites with the remainder of the acid into the common white muriat of lead. This change takes place ſtill more ſtrikingly with the brown oxyd. But when minium is employed in a large quantity, no oxymuriatic acid is produced, but, inſtead of it, the brown oxyd and common muriat of lead.[a]

The *carbonic acid* unites readily with the oxyd of lead, forming (as already mentioned) the white carbonat when fully ſaturated, and in a leſs proportion, converting the yellow oxyd to the ſtate of litharge. The proportions of theſe two carbonats have been already given. The white carbonat is produced by decompoſing the nitrat or any other ſalt by a carbonated alkali. Water holding carbonic acid will readily diſſolve enough of the oxyd of lead by remaining ſome time in contact, as to be very readily detected by the hydro-ſulphurets.

Ceruſſe or *white lead* is a carbonat prepared in the firſt part of the proceſs of making acetite of lead. It is made in the following way: lead is melted and caſt in a caſe or mould, ſo as to form a ſheet about two feet long, five inches broad, and from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch thick. The lead in this inſtance is caſt at once of the proper form, and not mechanically flattened like ſheet lead, that its texture may be more open, and more eaſily penetrated by the acid vapour. Theſe plates are then rolled up into a looſe coil, and each is laid perpendicularly in an earthen pot, like a common garden-pot, holding from two to ſix pints each, but with a ledge on the inſide about half way down on which the coil of lead reſts, ſo that it may not touch the bottom. Each pot is filled with vinegar of any kind, juſt ſo high as not to wet the bottom of the lead, and the whole is alſo covered with a plate of lead fitting very cloſe. The pots are then ranged under a building, ſo as to ſhelter them from the weather, and buried pretty deep in freſh ſtable litter or Tanner's bark, layer upon layer, according to the number of pots. The heat of the dung ſoon fills the upper part of the pots, with the vapour of the vinegar below, and the lead kept conſtantly in contact with the acid vapour, but not immerſed in the liquor, preſently begins to corrode and oxidate at the ſurface. The pots remain under the litter for about two months, at the end of which time they are taken out and the coils of lead are found deeply corroded and the ſurface converted into a whitiſh ſcaly brittle oxyd. This is ſeparated by paſſing the plates between rollers, which cauſes it to peel off, leaving the lead beneath in the metallic ſtate. This oxyd is then mixed with a little water, and paſſed between a pair of mill-ſtones; then the finer parts are ſeparated from the coarſer by ſucceſſive waſhings, the former being longer ſuſpended in water than the latter, till the whole of the finer oxyd is obtained. This is then dried either in the air or in large airy rooms warmed by a ſmall ſtove, and is then perfect ceruſſe or white lead fit for uſe. Of late years the ſcales of oxyd, inſtead of being ſeparated from the coils by dry laminating, which raiſed a duſt of lead highly injurious to the health of the people about them, are detached by ſpreading the coils upon a perforated wooden floor covered with water, and drawing them to and fro by rakes, which detaches the oxyd and cauſes it to ſink through the water and the holes of the floor to the bottom of the veſſel below.

The ceruſſe or white lead thus formed was found by Bergman to be a carbonated oxyd of lead, and not an acetite or ſub-acetite, though the acetous acid is the means of its formation.

The *acetous acid* does not diſſolve lead when in cloſe veſſels, but with acceſs of air it firſt oxidates it, and then diſſolves the oxyd. Or the ſolution may be made by adding oxyd of lead or carbonated oxyd to vinegar, and digeſting for a time.

Acetite of lead, commonly called *ſugar of lead*, is a ſalt uſed very largely in manufactures, particularly in calico-printing, and the preparation of it, though very ſimple, is confined to a very few places and countries. Moſt of the ſugar of lead uſed in this country is imported from Holland. This ſalt is made very nearly in the manner of ceruſſe, that is, lead ſheets are put into pots with vinegar and digeſted a ſufficient time, but here the vinegar is diſtilled, and the plates, inſtead of being entirely out of the liquor, are half immerſed in it.[b] This being done, the upper half is ſoon covered with an efflorefcence of ceruffe, after which it is immerfed in the vinegar, and the part which was before immerfed is now brought up to be converted into ceruffe as before, when the plate is again turned, and the newly oxydated furface in its turn buried in the liquor. The plates are thus turned about two or three times a day, and the vinegar in faturating itfelf with the ceruffe become milky, and foon fufficiently impregnated to be boiled down to the cryftallizing point, which is done in tinned veffels to about a third of the original quantity. This is then ftrained, and on cooling depofits the acetite in fmall long-needled irregular whitifh cryftals. The mother-liquor is again evaporated for a frefh crop of cryftals, but thefe are browner and fomewhat deliquefcent.

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[a] Fourcroy.

[b] Pontier Journ des Mines, No. 69.

Acetite of lead may alfo be made directly by diffolving ceruffe or litharge in vinegar, and probably the natural carbonat will anfwer the fame purpofe. Some technical nicety appears to be required in making the falt cryftallize in the large way.

Sugar of lead has a remarkably fweet tafte, by no means unpleafant, but mixed with confiderable aftringency. By re-folution in boiling water and flow cooling, it changes its appearance confiderably, and affumes the form of large tranfparent tetrahedral prifms or lengthened parallepipeds. Carbonic acid in any form decompofes this falt, and caufes a white carbonat to be precipitated, and hence one caufe of the milkinefs which it ufually affumes with fpring water, but this is alfo partly owing to the fulphats contained in moft natural fprings.

When dry acetite of lead is brifkly heated without addition in a retort, it gives an acetous red fetid liquor, and the refidue of the diftillation furnifhes a good pyrophorus. But Prouft,[c] in diftilling it very flowly, obtained firft a watery vinegar, then a yellow liquid with the fmell of alcohol but rather empyreumatic, from which after a time ammonia was difengaged, and from which, when faturated with potafh, a ftrong fmelling etherial oil feparated. The liquid diftilled from the folution furnifhed a ftrong inflammable fluid refembling ether.

Litharge boiled with vinegar to entire faturation forms a reddifh-brown folution, univerfally known in medicine as Goulard's extract, and it feems to contain much more oxyd of lead than the common acetite.

The *tartareous acid* has no direct action on lead, but added to the red oxyd it whitens it, and if a few drops of the acid in folution be poured into the liquid nitrat, or any other foluble falt of lead, a white pulverulent tartrite of lead is feparated.

Tartar, or the fuper-tartrite of potafh, is partially decompofed by the falts or oxyds of lead, the excefs of tartareous acid uniting with the lead, and neutralized tartrite of potafh remaining in the folution.

The *oxalic acid* readily tarnifhes metallic lead, but diffolves the oxyds with much more eafe. The folution when faturated depofits fmall brilliant cryftals, which foon grow opake in the air.

Similar cryftals of oxalat of lead are alfo obtained by adding oxalic acid to nitrat or acetite of lead.

The *malic acid* unites readily with lead when added to any of its foluble falts. The malat of lead is again decompofed by the fulphuric acid, which is the method propofed by Scheele of obtaining this vegetable acid pure. (See *malic acid.)*

The *arfenic* acid added to lead firft blackens and then converts it to a grey powder. Scheele[d] found that when one part of lead fhavings was diftilled with two parts of dry arfenic acid the lead was diffolved, a little arfenic fublimed, and in the retort was left a milky glafs, which, boiled in water, left a white powder which was arfeniat of lead. Arfeniat of lead is alfo formed immediately by adding arfenic acid or any other arfeniat to the nitrat acetite or moft other falts of lead. The natural arfeniats of iron and copper are ufefully analyzed in this way. (See vol. i. page 102 and 332.)

Arfeniat of lead is however decompofed by fulphuric acid, and the arfenic acid left in the folution while the fulphat of lead fubfides. It is alfo foluble in acetic acid, which the fulphat of lead is not.

Many other of the acids unite with lead, forming falts little known, which will be found under thofe refpective acids.

The fixed alkalies diffolve the oxyd of lead, either by direct combination or by decompofing any of the acid falts of this metal by the alkali, and rediffolving the precipitated oxyd by an excefs of the alkali. None of the falts, however, can be completely decompofed in this way, for it is not ftrictly an oxyd that precipitates, but an infoluble falt compofed of the acid and an excefs of oxyd; as for example, when the muriat of lead is ufed, the precipitate is muriatic acid with an over proportion of oxyd (or a *fub-muriat)* and thereby rendered infoluble in water alone, and the alkali only diſſolves this exceſs of oxyd. But the carbonated alkalies completely decompoſe the ſalts of lead.

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[c] Journ. de Phyf. vol. lvi. p. 208.

[d] Effays.

The alkaline earths alſo diſſolve the oxyds of lead. The action of lime-water has been minutely examined by Berthollet.

Lime-water boiled for a long time on litharge forms a ſolution which has been long known as a recipe for blackening hair and other animal matters. When evaporated in a cloſe veſſel it depoſits ſmall tranſparent cryſtals of lime with oxyd of lead. This ſolution is decompoſed by the alkaline ſulphats and muriats, and alſo by ſulphuretted hydrogen.

Ammonia alſo diſſolves oxyd of lead but with difficulty, and it does not decompoſe the acid ſalts of this metal ſo readily as the fixed alkalies do.

Lead and nitre have but a very weak action on each other. When lead filings are projected on melted nitre, little if any deflagration is excited, but the metal is reduced to a yellow ſemi-vitrified foliated maſs reſembling litharge.

The action of the oxyds of lead on the alkaline muriats is attended with ſome ſtriking phenomena. In the numerous experiments for obtaining the alkali from muriat of ſoda, it was found that litharge was able completely to decompoſe this ſalt and produce a white maſs, whilſt the naked alkali remained in ſolution. This diſcovery has been applied to uſe in the large way on account of the fine yellow pigment which is obtained from the white maſs by calcination, and for which a patent was procured many years ago by Mr. Turner.

Vauquelin has elucidated this intereſting chemical phenomenon in his uſual maſterly manner.[c] He obſerves that we cannot admit this decompoſition to be the reſult of ſimple affinity without involving a direct contradiction, for if the oxyd of lead had a ſtronger affinity than ſoda for muriatic acid, muriat of lead could not be decompoſed by ſoda, which however is readily done to a certain extent. Nor can the carbonic acid of litharge be concerned in the explanation, ſince minium, which contains no carbonic acid, operates in decompoſing muriat of ſoda full as powerfully as litharge does.

But on the other hand muriat of ſoda is *completely* decompoſed by litharge, if the latter be in ſufficient quantity, ſo that this apparent contradiction cannot be explained by ſuppoſing the decompoſition only partial, but recourſe muſt be add to more complicated affinities.

The facts and experiments given by Vauquelin are the following: ſeven parts of litharge in fine powder were mixed with one of muriat of ſoda; the whole was moiſtened with water to the conſiſtence of thin ſoup and frequently ſtirred during ſeveral hours. By degrees the litharge loſt its natural colour, whitened, and ſwelled prodigiouſly, abſorbing all the water that was uſed at firſt, ſo that to prevent its hardening, it was neceſſary to add much more. As no further change took place after four days, the whole was examined. The liquid when filtered had a ſtrong alkaline taſte, and contained alſo a little muriat of lead but no muriat of ſoda. By evaporation it furniſhed cryſtals of carbonat of ſoda, rendered opake by a ſmall portion of muriat of lead. The ſubſtance from which the liquor had been ſeparated, when dried and waſhed, was of a dirty white, and weighed $\frac{1}{8}$ more than the litharge uſed. Heated gently it aſſumed a very fine lemon-yellow, loſing thereby about $\frac{1}{40}$ of its weight.

Part of this yellow ſubſtance digeſted with cauſtic ſoda changed to a dirty yellow, diminiſhed in ſubſtance, and the undiſſolved reſidue now changed from a powder to a cluſter of needled cryſtals. The alkaline liquor retained its natural taſte, but gave a copious black precipitate with hydroſulphuret of ſoda, ſhewing the preſence of much oxyd of lead. The needled cryſtals were common muriat of lead.

The white ſubſtance therefore left after the action of muriat of ſoda on litharge was muriat of lead with a great exceſs of oxyd (which laſt the ſoda diſſolved) or in other words a *ſub-muriat of lead.*

The ſame was alſo treated with weak nitric acid, which diſſolved all the exceſs of oxyd and left a white cryſtalline muriat of lead. The nitric ſolution gave by evaporation cryſtals of nitrat of lead mixed with ſome muriat.

Another portion of the ſame yellow ſubſtance was boiled with water but ſcarcely any was diſſolved, which inſolubility is therefore owing to the exceſs of oxyd, ſince common muriat of lead diſſolves in about 22 parts of hot water.

This ſub-muriat therefore has the following properties: it is inſoluble in water; cauſtic alkalies and nitric acid diſſolve only the exceſs of oxyd, and it is alſo owing to this exceſs that it aſſumes the yellow colour when heated.

Muriat of lead however cannot be entirely decompoſed by cauſtic ſoda, for when theſe two ſubſtances are digeſted together, ſufficient muriatic acid always remains combined with the oxyd of lead to bring it to the ſtate in which it is found after the decompoſition of common ſalt, that is, of the *ſub-muriat*, which is proved by its becoming yellow when heated, and when treated with nitric acid, by yielding nitrat of lead, and common muriat of lead.

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[c] Ann. Chem. tom. xxxi.

In the above experiments a ſingular complication of affinities operates.

According to Vauquelin, when the yellow ſub-muriat of lead is treated with cauſtic ſoda, cryſtallized muriat of lead and a ſolution of ſoda are produced; ſo that this alkali has the power of abſtracting the exceſs of oxyd from the ſub-muriat: yet on the other hand, the cryſtallized muriat is decompoſed by ſoda into the ſub-muriat and muriat of ſoda; and an additional quantity of ſoda beyond what was neceſſary to ſaturate the muriatic acid, would again decompoſe the ſub-muriat formed by the firſt portion, and by uniting with its exceſs of oxyd, would reſtore what remained undecompoſed, to the ſtate of cryſtallized muriat of lead.

Hence a large proportion of litharge is required to decompoſe common ſalt, for as cauſtic ſoda is actually produced in the proceſs, it would in its turn react upon the ſub-muriat of lead and deprive it of its exceſs of oxyd, unleſs this alkali had already met with ſufficient oxyd of lead to ſaturate it. So that the affinities here acting, are thoſe of muriatic acid for oxyd of lead, of muriat of lead for an exceſs of oxyd, and alſo of ſoda for oxyd, and there muſt therefore be ſufficient oxyd to anſwer all theſe diſtinct affinities, and ſupply each of the ſubſtances mentioned with their ſeparate portion.

According to Vauquelin alſo, there is a ſub-nitrat and a ſub-ſulphat of lead, made alſo by adding to the common ſulphat and muriat a ſmall quantity of cauſtic alkali, particularly ammonia, by which the ſub-ſulphat or ſub-nitrat is precipitated.

Turner's Patent Yellow, or the ſub-muriat of lead made yellow by heating, is thus made according to the ſpecification of the patent:[f] take any quantity of minium, litharge, or calx of lead, add half the weight of common ſalt, with water ſufficient to diſſolve it, mix them by long trituration, and let them ſtand together at leaſt for twenty-four hours, by which time the lead will be changed into a good white, then waſh out the alkali and calcine the lead till it becomes yellow; which will be of different tints according to the continuance of calcination and degrees of heat. As only twice as much litharge as ſalt is here employed, it is probable that ſome of the ſalt remains undecompoſed.

The oxyds of lead readily decompoſe muriat of ammonia. If this ſalt and minium are rubbed together even without heat, a ſtrong ſmell of ammonia riſes, and by diſtillation properly conducted, cauſtic ammonia may be prepared in this way as well as by muriated ammonia and lime. If litharge be uſed, ſome carbonat of ammonia is alſo obtained, and with the white carbonat of lead the entire ammoniacal product is carbonated. The reſidue in each caſe is muriat of lead, in the form of a grey brilliant brittle maſs.

Borax readily unites with all the oxyds of lead by fuſion into a fine ſoft yellow glaſs.

Lead unites with *Sulphur* with great eaſe. This may be effected either by adding ſulphur to melted lead, or by heating alternate layers of ſulphur and lead clippings in a crucible. The proportions are of little importance, two or three parts of lead to one of ſulphur are generally uſed. The reſult is a black ſcaly powder. When the mixture is heated to a certain point it takes fire, and the exceſs of ſulphur flies off. Sulphuret of lead is fuſible, but requires a red heat, being leſs eaſily melted than either of its conſtituent parts.

When ſlowly cooled after fuſion, it forms a black, harſh, brittle maſs, readily cryſtallizing in cubic facets, particularly if the fluid part of the maſs is poured off when the ſides have fixed by cooling. This artificial ſulphuret much reſembles the natural galena in appearance.

Sulphuretted alkali acts with extreme energy on lead, diſſolving it readily by fuſion.

All the *Hydroſulphurets* either with or without an alkaline or earthy baſis immediately unite with lead in any liquid combination, whether diſſolved by acids or alkalies, or alkaline earths, and produce a very dark brown hydroſulphuret which being inſoluble ſlowly falls to the bottom of the liquor. In this way very minute portions of lead are readily detected in wines and other liquids that may be ſuſpected to contain this dangerous metal. Sulphuret of potaſh or of lime diſſolved in water forms a hydroſulphuret very proper for this purpoſe, or ſulphuretted hydrogen gas ſimply diſſolved in water will anſwer as well. But as the ſalts of iron and ſome other metals are equally blackened by this teſt, ſome method of diſtinction is adviſeable when liquors are to be examined with regard to their ſuppoſed noxious qualities. This is partly effected by adding a weak acid, ſuch as the tar-

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[f] Repertory, vol. xii.

tareous to the ſulphuretted teſt, which will rediſſolve the hydro-ſulphuret of iron, but not that of lead. (See *Wine*.)

Phoſphorus eaſily unites with lead according to Pelletier's experiments,[g] by melting in a covered crucible a mixture of one ounce of vitreous phoſphoric acid, one dram of charcoal, and one ounce of lead clippings.

The phoſphuret is conſiderably malleable, and little different from common lead in appearance, but when heated the phoſphorus burns off. It readily tarniſhes in the air. It is alſo made by projecting phoſphorus on melted lead.

The fat oils diſſolve the oxyds of lead with great eaſe, and undergo a remarkable change in the proceſs, being thereby rendered *drying*, or capable of ſpeedily hardening into a firm varniſh when expoſed to the air. Some oils, particularly olive oil, acquire at once a very firm conſiſtence and a conſiderable adheſive property, when gently warmed. It is in this ſtate the common white *diachylon plaſter*. See the articles OIL and PLASTER.

Lead is capable of uniting with many other metals, forming alloys, ſome of which are of uſe in the arts.

With antimony lead forms an alloy which is brittle, when the latter exceeds about ¼. In addition to what is mentioned under the article *Antimony*, ſome experiments of Prof. Gmelin may be noticed.[h] The lead was firſt melted ſeparately, and when fuſed a little ſuet was thrown on the ſurface; after which the antimony was thrown in, in powder, the whole well ſtirred, and poured out without loſs of time into an iron mould. Equal parts of the two metals produced a cloſe alloy of lamellar texture, of conſiderable luſtre in the fracture, and very brittle. Sp. gr. 7.22. Two parts of lead and one of antimony gave a leſs brilliant alloy, of a granular texture, yielding a little to the hammer. Sp. gr. 11. Three of lead and one of antimony gave an alloy of a duller colour, granular, and extending moderately under the hammer.

Four of lead and one of antimony forms, according to Rinman and other authors, the common type-metal of the letter-founders, though ſome add a little copper or braſs. This reſembled the laſt-mentioned alloy in appearance, and would not take a poliſh. Sp. gr. 9.571.

Eight parts of lead and one of antimony gave an alloy very like pure lead, but harder and more ſonorous, and of a cloſe granular texture like ſteel. Sp. gr. 11. Twelve of lead and one of antimony gave an alloy ſcarcely leſs malleable than lead, and capable of extending into very thin leaves.

Antimony therefore is found to harden lead very conſiderably, and hence its uſe in type-metal, and alſo probably in bullets, where greater hardneſs is required, but it does not add materially to its luſtre, except in a quantity which totally deſtroys the malleability.

Lead and biſmuth unite with great eaſe, and form alloys of remarkable fuſibility, particularly with a ſmall addition of tin, as deſcribed under the article *Biſmuth*.

Lead and cobalt unite but with difficulty, forming an unimportant alloy. (See COBALT.)

Lead alloyed with copper forms *pot-metal*. (See COPPER.)

For the important alloy of lead and tin, ſee TIN.

Lead and zinc do not unite readily unleſs by particular management. Beaumé found that when ſimply melted together, and cooled ſlowly the lead fell to the bottom of the crucible, and the zinc remained at the top unmixed. Beſides, if they are kept together in fuſion and repeatedly ſtirred, the zinc ſublimes off with great rapidity. But Gmelin[i] ſucceeded completely in alloying theſe metals by firſt melting the lead, covering it with ſuet, then throwing in the zinc, and as ſoon as the latter appeared to be uniformly mixed (probably by help of ſtirring) and the blue zinc-flame began to appear, removing the crucible, and ſuddenly cooling the mixture by pouring it into an iron ſpoon. Some of the reſults of theſe experiments we ſhall mention: Equal parts of lead and zinc gave a metal of a lamellated texture, ſo ductile as to bear hammering into a pretty thin blade, harder than lead, and very bright when juſt filed. Sp. gr. 7.66.

Three of lead and one of zinc gave an alloy more leaden in appearance, but harder, more ſonorous, and brighter. Four of lead and one of zinc gave an alloy ſtill more leaden, but yet ſenſibly harder and capable of a good poliſh. Twelve parts of lead and one of zinc ſtill retained a much greater degree of hardneſs, ſonorouſneſs, and luſtre on the poliſhed ſurface, than pure lead. Sixteen parts of lead and one of zinc ſcarcely differed from lead in appearance, but the ſpecific gravity was leſs, being only 10.617.

The affinities of the oxyd of lead to the different acids are in the following order.[k] The ſulphuric, ſaccholactic, oxalic, arſenic, tartaric, muriatic, phoſphoric, ſulphureous, ſebacic, nitric, fluoric, citric, lactic, acetic, boracic, pruſſic, and carbonic acids.

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[g] Memoires, tom. i. & ii.

[h] Comm. Soc. Gotting. tom. x.

[i] Comm. Gott. ibid.

[k] Thomſon.

LEAD (WHITE) or *Ceruſſe*. (See the foregoing article.)

LEAD (SUGAR OF) or *Acetite of Lead*. (See the foregoing article.)

LEATHER.

The preparation of the ſkins of animals for the many important purpoſes to which they are applied is almoſt excluſively a chemical proceſs in all its branches, and as ſuch will deſerve a general notice in this place.

The art of preparing leather is unqueſtionably one of the moſt ancient known, and is practiſed in every country on the face of the globe with a general ſimilarity of method, the reſult of obvious reaſoning, and long experience.

The objects fulfilled in converting ſkin into leather are to prevent the deſtruction by putrefaction, which unprepared ſkin would undergo (though ſlower than with moſt other parts of animals) and to render it ſtrong, tough, and durable, and in ſome inſtances impervious to moiſture.

The recent ſkin ſtripped off an animal conſiſts principally of the true cutis, or membranous texture, the chemical compoſition of which is gelatin in a denſe ſtate, but ſtill entirely ſoluble in water more or leſs eaſily, according to its denſity. This however is penetrated with different veſſels for blood, lymph, oil, &c. ſome of the contents of which muſt of neceſſity remain after the death of the animal, and is covered on the outſide with the inſenſible cuticle to which is attached the exterior covering of hair, wool, fur, and the like. The chemical compoſition of the cuticle and its inveſting hairy covering, appears to be condenſed albumen, inſoluble in water, and nearly incapable of itſelf of putrefaction, but readily ſeparable from the true ſkin by ſlight mechanical violence after the adheſion has been weakened by incipient fermentation or putrefaction, or the chemical action of lime, alkalies, or acids.

The preliminary ſteps of all the proceſſes for making leather conſiſt in ſeparating from the cutis adhering impurities and foreign matters, the animal juices retained in its pores, and the cuticle with its hairy covering, (except on the very few caſes in which the latter is purpoſely left on.) The true ſkin being thus obtained nearly pure, and its texture ſo far opened as readily to imbibe any ſubſtance in which it is macerated, is then converted into leather in different methods, of which there are two quite diſtinct from each other: namely, that of *tanning*, or impregnating it with that peculiar vegetable matter called tan, and *tawing*, in which it imbibes alum and other ſalts, and afterwards ſome ſoluble animal matter, ſuch as the white of egg, or ſometimes blood. Theſe two proceſſes are alſo ſometimes combined, that is, firſt by tawing, and afterwards finiſhing with a ſlight tanning. A large portion of the tanned leather alſo undergoes the further operation of *currying*, or imbuing with oil of ſome kind with much manual labour, in order to render it ſupple, flexible, and ſtill more impenetrable by water. As familiar examples of each, the thick ſole-leather of ſhoes is *tanned*; the white kid leather, as it is called, for fine gloves, is *tawed*; the upper leather for boots and ſhoes is *tanned* and *curried*; and the fine Turkey leather is *tawed*, and afterwards finiſhed with a ſlight *tanning*.

The ſlight variations in the preparation of different kinds of leather are ſo numerous, that only ſome of the leading proceſſes can be here deſcribed.

Tanned leather. All ſkins undergo a conſiderable preparation before they are fit to receive the tanning lixivium. In moſt parts of England the proceſs is the following for the thin ſkins of cows, calves, and thoſe that are uſed for the more flexible kinds of leather, moſt of which is afterwards finiſhed by currying. The hide is firſt thrown into a pit with water alone to free them from looſe dirt, blood, and other impurities. After lying there for a day or two it is placed upon a ſolid half-cylinder of ſtone, called a *beam*, where it is cleared of any adhering fat or fleſh. It is then thrown into a pit containing lime and water, in which it is kept for ſeveral days with frequent ſtirring. The uſe of this is to looſen the hair and cuticle, after which the hide is again ſtretched on the beam and the hair entirely ſcraped off with a blunt knife made for the purpoſe. The hide being well freed from the lime is then put into a pit called the *maſtering*-pit, which is a bath compoſed of water and the dung of ſome animal, generally hens or pigeons, or dogs, or, where it can be had, of ſea-fowl, diffuſed through the water. The dung of horſes or cows will not anſwer, not being ſufficiently putreſcent. Here the hide remains for ſome days, more or leſs, according to its texture, and from being hard and thick (the effect of the lime-water) it becomes very ſoft and ſupple. Where the hide is very thin and fine, extreme care is requiſite in regulating this part of the proceſs, for the putreſcent dung is found ſo powerful an agent, that if the ſkin is kept in it only a few hours too long its texture is irrecoverably deſtroyed, and it is reduced to a gelatinous maſs, which pulls to pieces with the ſlighteſt force. The hide is then thoroughly cleaned on the beam, and is fit for tanning.

The large thick ox or boar's hides intended for the tougheſt ſole-leather, or where a very ſtrong leather is required, are prepared in a different way. Being firſt cleaned in water, they are ſometimes rolled up in heaps and put into a warm place where they ſpeedily begin to putrify. The hair is then looſened, and may be ſcraped off ſometimes with, and at other times without, the proceſs of liming. The reaſon why the liming is generally omitted is that the lime, if retained in the ſkin, renders it too hard and liable to crack, and it is not ſo eaſy to waſh it out from theſe as from the thinner hides. But on account of the thickneſs of the hide and the cloſeneſs of its texture it is not fitted to receive the tan liquor till its pores are more completely opened, and this is uſually done by immerſing it for ſeveral days in a vat containing a ſour liquor, an impure acetous acid, formed from rye or barley flour ſtrongly fermented. The acid generated in the proceſs ſeems to be a principal agent in opening the texture of the ſkin, but this is doubtleſs aſſiſted by the continuance of the fermentation, of which the ſkin itſelf partakes. This proceſs is called *raiſing*, and it always immediately precedes that of tanning. Here alſo much care is required not to weaken the texture of the ſkin too much, for if kept too long in this proceſs it would be corroded and ſpoiled. The hide comes out of this bath conſiderably ſwelled and ſoftened.

Inſtead of this part of the proceſs, which is often difficult to manage properly on account of the effect of the weather and other external cauſes on the neceſſary fermentation, Dr. Macbride has propoſed the uſe of ſulphuric acid extremely diluted, and this appears now to be pretty generally adopted. The proportions employed are about a wine pint of oil of vitriol to fifty gallons of water. Though the vitriolic bath is found to have as good an effect as the rye and barley ſourings in preparing the hides for the tan, the action of the two ſubſtances ſeems to be conſiderably different. In the latter the acetous acid is doubtleſs the chief agent, but the fermentation ſtill continues as is proved by the readineſs with which the ſkins are rotted if this is too high or too long continued. The ſkin alſo after raiſing in this way is thickened and ſoftened. But the vitriolic bath is incompatible with any fermentation, and moſt powerfully checks this proceſs, and hence the ſkin is not readily ſpoiled by very long immerſion, and it comes out thickened and hardened. It ſhould ſeem however that each method anſwers perfectly well.

The next proceſs is that of *tanning*, which is eſſentially the ſame for all ſkins, however previouſly prepared, and is founded on the following chemical facts. A great variety of vegetable ſubſtances, that is all thoſe that give an aſtringent taſte when chewed (ſuch as the bark of oak, willow, alder, and many other trees, the gall-nut, tea-leaves, &c. &c.) when macerated in water, hot or cold, yield to this menſtruum a ſubſtance eminently aſtringent, of a greyiſh-white when pure, which is called *tannin* or *tan*, whoſe properties will be more fully deſcribed under that article. When any kind of ſkin is ſoaked in an infuſion of tan it gradually abſorbs it or extracts it from the water in which the tan is diſſolved, and the ſkin thereby becomes of a firmer texture, ſenſibly heavier, no longer capable of putrefaction or any ſpontaneous change, leſs eaſily pervious to water, and no longer ſoluble in this fluid even at a boiling heat, which all untanned ſkin is, whatever be its previous preparation. The art of tanning therefore eſſentially conſiſts in nothing more than immerſing ſkin for a ſufficient length of time in an infuſion of tan from vegetable bark or other ſources till it is completely ſaturated with this principle. Hence the art of preſerving the hides of animals by this method is one of the moſt antient and univerſal of all manufactures, no apparatus whatever being required to perform it, except a pit or hole of water in which the tanning vegetable may be put, and the ſkin thrown in along with it. And even in the moſt careful and improved methods of tanning, almoſt equal ſimplicity is obſerved in the operation, except that ſome art is uſed in regulating the ſtrength of the tan-infuſion, and ſome little manipulation in ſtirring the hides to give every part an opportunity of being thoroughly and equally ſoaked.

The ſubſtance uſed for tanning in this country is almoſt invariably oak-bark. The timber being felled in ſpring (when the ſap has riſen) the bark is ſtripped off and piled in large ſtacks, protected from the wet by a ſhed, but open at the ſides to admit a free circulation of air through it. The bark before uſing is ground into coarſe powder, and is thrown into pits with water, by which an infuſion of the tan and other ſoluble parts is made, which is called technically *ooze*. The hides previouſly prepared in one or other of the ways above mentioned are then put firſt into ſmall pits with a very weak ooze, where they are allowed to macerate for ſome weeks with frequent ſtirring or *handling* as it is called. The ſtrength of the different oozes is increaſed gradually, after which the half-tanned hides (if of the thick kind intended for ſole-leather, and which require very complete tanning) are put into larger pits with alternate layers of ground bark, in ſubſtance, till the pit is filled, over which a heading of bark is alſo laid, and the interſtices filled up with a weak ooze to the brim. The hides thus are expoſed to the full action of an ooze nearly ſaturated with tan, and ſupplied with more of this principle from the bark in ſubſtance, in proportion as the ſkin abſorbs that portion already diſſolved, till the tanning is judged to be complete. This for the heavieſt kind of leather requires never leſs than fifteen months. Skin is known to be fully tanned by cutting a ſmall piece off the edge of the hide, and obſerving the change of colour. As far as the tan has fully penetrated, the colour is of a nutmeg-brown, but the reſt is white; and therefore before the proceſs is complete the upper and under ſides are brown, and a white line or ſtreak is ſeen in the middle.

Laſtly, when fully tanned the hide is taken out to drain, and ſtretched upon a convex piece of wood called a *horſe*, on which it is thoroughly ſmoothed, and beaten with a heavy ſteel pin, or ſometimes paſſed between iron cylinders, to make it more ſolid, and at the ſame time ſupple, after which it is taken to the *drying-houſe*, a covered building with apertures for the free admiſſion of air, where it remains till perfectly dry.

The common calves-ſkins require for the whole proceſs of converſion into leather in this way from two to four months, the thick ſole-leather hides from fifteen to eighteen or twenty months, and a boar's ſhield can hardly be finiſhed in leſs than two years. Leather gains in weight and improves in quality the longer it is ſuffered to remain in the ooze (within certain limits), and, as it is ſold by weight, this is alſo ſometimes an object to the tanners, though counterbalanced to a great degree by the length of time that muſt elapſe before his capital is returned.

The art is indebted to M. Seguin, a tanner of extenſive buſineſs in France, for the firſt accurate explanation of the rationale of the proceſs of tanning. According to the ancient idea of this proceſs the effect of the infuſion of aſtringent vegetables was ſuppoſed to be little elſe than mechanical, and that it acted in *conſtringing* or *condenſing* the fibres of the dead ſkin, as it corrugates the ſkin of the palate when taſted, and hence rendered it nearly impervious to moiſture and unſuſceptible of putrefaction. This explanation however did not accord with the actual increaſe of weight which the ſkin acquires by tanning, and which amounts on an average to an increaſe of from one-third to one-fourth of the weight of the ſkin when dry. M. Seguin, reaſoning from the circumſtance that ſkin before tanning is completely reſolved by water into a liquid jelly, but is inſoluble after tanning, was led to the ſimple experiment of adding a ſolution of ſkin (or glue) to an infuſion of oak-bark, and found an immediate precipitate of a thick tough extenſible dun-white matter, ſtrongly ſmelling of tan, and inſoluble in water at any heat, and which when dry becomes of a dark-brown colour and brittle.

This precipitate is an intimate combination of gelatin with that part of the vegetable infuſion which gives the tanning property, and being altogether a peculiar ſubſtance is denominated *tannin* or *tan*, whoſe properties will be more fully deſcribed under that article. This precipitate therefore hardly differs from tanned leather in any thing but in wanting the fibrous organized texture, and what other principles the ſkin may have abſorbed from the bark-infuſion during the maceration of ſeveral months, which a ſudden precipitation would not effect. Tanning therefore conſiſts chiefly in a ſlow and moſt intimate combination of vegetable *tan*, with the fibre of the ſkin, which continues till the latter is ſaturated through its whole thickneſs.

But oak-bark contains other ſoluble matter, which certainly alſo enters the texture of the ſkin along with the tan, and moſt intimately combines with it, for ſkin, when it has undergone the previous preparation already mentioned, appears to be able to abſorb, and when abſorbed to retain a great variety of vegetable and animal ſubſtances. The infuſion of oak-bark contains, beſides tan, the gallic acid and an extractive matter, all of which contribute to the proceſs, and form a part of the tanned leather. That the gallic acid is abſorbed is proved by the inſtant blackneſs which the leather aſſumes when merely rubbed with a ſolution of any ſalt of iron. The extract appears to be that which gives the leather its colour, and ſome degree of flexibility, and from the excellent obſervations of Mr. Davy on the proceſs of tanning° it ſeems probable that the quantity of tan abſorbed is a good deal regulated by the quantity of extract preſent, being in general (the time of immerſion and ſtrength of the tan-infuſion being nearly equal) in *inverſe* proportion to the quantity of extract or of mucilage preſent in the infuſion. This is found by comparing the actual weight acquired by leather, by quick tanning in infuſions of different tanning materials, the compoſition of which has been previouſly aſcertained by chemical analyſis. The difficulty in experiments of this kind of obtaining tolerable accuracy is however very great, much greater than in the analyſis of metals or minerals, on account of the great want of characteriſtic marks of diſtinction between vegetable matters, when a little changed by chemical union with other bodies, and the readineſs with which their characters are irrevocably loſt by the common action of re-agents.

The ſtrength of the tanning infuſion alſo moſt materially affects the quality of the leather and the weight which the ſkin gains during the proceſs. As tan is more ſoluble than extract, a ſolution made haſtily, and with a large portion of the material, will be nearly ſaturated with tan, and contain comparatively but little extract; and on the other hand the reſidue of the above infuſion, macerated for a longer time in freſh water, will give a ſolution in which there is but little tan, but a large quantity of extract. Now it would ſeem that ſkin has the power of fixing a larger quantity of tan than of any other material, particularly than of extract, ſo that if already nearly ſaturated with extract, it will of courſe abſorb much leſs tan than before, and therefore the entire increaſe of weight will be much leſs in this way than with tan alone. The quality alſo of the leather will of courſe be probably different when compounded of ſkin and tan with very little other ingredients than when it is a compound of ſkin and tan with a larger portion of extract; and in particular the former ſeems to be more brittle and leſs urable than the latter, as far as experiments have hitherto been made. The mere duration of the proceſs alſo, as regulated ſolely by the ſtrength of the infuſion, that is where preciſely the ſame infuſion is uſed, but more or leſs diluted, may probably conſiderably affect the quality of the leather, for when the proceſs goes on very rapidly it is poſſible that the outer part of the ſkin may be tanned ſtrongly before the inner part is penetrated with the liquor, and as tanning gives a cloſeneſs of texture and difficult permeability to liquids it may happen that this very circumſtance may prevent that uniformity of ſaturation with tan which would ſeem deſirable.

The precipitate made by a ſolution of gelatin dropped into an infuſion of any tanning vegetable matter appeared by Mr. Davy's experiments to be tolerably uniform in its compoſition whatever be the other conſtituents of the vegetable infuſion. Thus when galls were uſed the precipitate contained about 46 of tan and 54 of gelatin, with catechu it contained 41 per cent. of tan, with oak bark 41 per cent. and with the Leiceſter willow 43. But real ſkin will never acquire ſuch an increaſe of weight as the ſolution of gelatin either becauſe other ſubſtances enter the compoſition of leather, or becauſe the texture of the ſkin will not allow it to condenſe and chemically unite with ſo much tan as the ſame ſkin when diſſolved in the form of glue, for glue (as mentioned under the article *Gelatin*) is only a ſolution of the refuſe part of ſkin. Thus it was found that a piece of ſkin compleatly tanned by three week's immerſion in a ſtrong infuſion of galls only gained weight in the proportion of 39 to 61 of ſkin; and this was even the greateſt increaſe of weight obſerved, (being much more than that of common leather,) and in conſequence made a much harder and more brittle leather.

With regard to the effect produced by the time of immerſion, it was found in different experiments that ſkin apparently equally well tanned in each caſe, abſorbed much more tan by rapid than by ſlow tanning: 100 parts of leather prepared in 2 weeks, containing 73 of ſkin and 27 of tan and other materials abſorbed from the oak bark infuſion, and the ſame quantity of leather prepared in 12 weeks (the infuſion being proportionably weaker) containing 85 of ſkin and 15 of tan and other vegetable matter. A ſimilar difference was found when infuſion of willow bark was employed.

° Jour. Royal Inſtit. and Phil. Tranſ. for 1803.

The ſuppoſed improvement in the proceſs of tanning practiſed and actually propoſed by M. Seguin may here be ſhortly mentioned. This ingenious artiſt wiſhing to abridge the enormous time employed in common tanning (and conſequent expence) and conſidering the tan as nearly the only active principle in this proceſs, adopted the plan of uſing ſolutions of tan, inſtead of the mixture of bark and ooze uſually employed, and of ſeveral and known degrees of ſtrength in which the ſkin might be rapidly paſſed from the weakeſt to the ſtrongeſt by a more regulated gradation than is uſually done. For this purpoſe he had a ſeries of vats containing the oak-bark, and began by pouring water on one of them, and after a ſhort time drawing it off clear through a hole at the bottom. This firſt ooze was then poured on the bark of the ſecond vat, and drawn off as before, by which it became ſenſibly ſtronger of tan. This liquor again was uſed to the third vat, and again to a fourth, according to the number, till it became quite ſaturated with tan. In the mean time freſh water was poured on the bark of the different vats in the ſame order, which produced a ſecond ooze ſtill very ſtrong but inferior to the firſt: and thus three or four or more different oozes were obtained, all differing in ſtrength, and which was the tanning liquor employed. The ſkins then being previouſly prepared in the way already deſcribed, were paſſed ſucceſſively through the different oozes, beginning with the weakeſt and aſcending to the ſtrongeſt till they were compleatly tanned, which was known by the diſappearance of the white line in the middle of the ſkin when cut through.

It appears beyond a doubt that the proceſs of tanning is moſt materially ſhortened by this method of M. Seguin, and that very perfect leather is produced, but though now known for ſeveral years it does not appear to be adopted to any extent in this country, where leather is manufactured in vaſt quantities both for home conſumption and for exportation to many parts of Europe, in which Engliſh leather is in the higheſt repute. From the way in which the oozes are made, according to M. Seguin, they muſt of neceſſity contain much more tan in proportion to the extract and other vegetable matter than where the bark itſelf is ſuffered to remain in ſubſtance along with the ooze and ſkin for many months, as the tan is much the moſt ſoluble of all the ſubſtances that are to be extracted by water, ſo that bark may readily be exhauſted of tan, long before the extract, reſin, gallic acid, and other materials are got out. It is ſaid that the leather prepared in this new method is leſs durable and more brittle than in the old way.

The only real improvement of late adopted in this part of the proceſs is to uſe ſome of the oozes warm by which the ſkin is ſooner penetrated with the ooze, and a ſaving of time made of ſome conſequence.

Dr. Macbride propoſes lime-water to be uſed inſtead of common water for the extraction of the tan from the oak-bark, but this ſeems to be miſchievous, as the only aſſignable effect of the lime would be to contract a firm union with a portion of the gallic acid and the tan, the reſult of which would be an inſoluble calcareous ſubſtance utterly unfit for any purpoſes of tanning.

Of Tawing, Leather-dreſſing and dyeing, and other proceſſes.

The dreſſing and preparing of the ſkins of lambs, ſheep, goats, and other thin hides, though in many particulars cloſely reſembling the method uſed with the thick cow and ox hides, forms uſually a totally diſtinct branch of buſineſs, and is one in which a good deal of practical ſkill and nicety of manipulation is required to ſucceed perfectly. The proceſſes are very various according to the article required, and this branch of the manufacture ſupplies the immenſe demand of white and dyed leather for gloves, the (ſo called) morocco leather of different colours and qualities for coach linings, book-binding, pocket-books, and thin leather for an infinite number of ſmaller purpoſes. Of theſe the white leather alone is not tanned but finiſhed by the proceſs of tawing, but the coloured leather receives always a tanning (generally by ſumach) independent of the other dyeing materials. The previous preparation of each, or that in which the ſkin is thoroughly cleanſed and reduced to the ſtate of ſimple membrane in which it is called *pelt*, is eſſentially the ſame whether for tawing or dyeing. It is thus performed at the beſt manufactories at Bermondſey, near London, a place long celebrated for all branches of the leather buſineſs.

By far the greater number of the ſkins are imported: if lambs they are thus prepared; the ſkins are firſt ſoaked for a time in water, to cleanſe them from any looſe dirt and blood, and put upon the beam commonly uſed for the purpoſe, which is a half cylinder of wood covered with ſtrong leather, and ſcraped on the fleſh ſide with the ſemicircular blunt knife with two handles uſed in this operation. They are then hung up in conſiderable numbers in a ſmall cloſe room heated by flues, where they remain to putrefy for a given time, as is eaſily perceived by the ſtrong ammoniacal odour which iſſues from them when the door is opened. During this proceſs a thick filthy ſlime works up to the ſurface of the ſkin, by which the regularity of the proceſs is judged of; and the wool is looſened ſo that it readily comes off with a ſlight pull. Each ſkin is then returned to the beam, the wool taken off and preſerved, and all the ſlime worked off with the knife, and the rough edges pared away. The ſkin is then put into a pit filled with lime water and kept there from two to ſix weeks more or leſs according to the nature of the ſkin, which has the effect of checking the further putrefaction, and produces a very remarkable hardening and thickening of its ſubſtance, and probably alſo it detaches a further portion of the ſlime. The ſkin is again well worked upon the beam, and much of its ſubſtance pared down, and all inequalities ſmoothed with the knife. Much pains and judgment are required in theſe operations on the one hand not to endanger the ſubſtance of the ſkin by the putrefaction (which if carried on too long would ſoon reduce it to an incoheſive pulp) and on the other hand to work out every particle of the ſlime, the leaſt of which if retained will prevent the ſkin from dreſſing well in the ſubſequent proceſſes, and from taking the dye uniformly and well. The ſkin is then again ſoftened and freed from the lime by being thrown into a vat of bran and water, and kept there for ſome weeks in a ſtate of gentle fermentation, being occaſionally returned to the beam. All the thickening produced by the lime is thus removed, and the ſkin is now as highly purified as poſſible, and is a thin extenſible white membrane called in this ſtate a *pelt*, and is now fit for any ſubſequent operation of tawing or dyeing, or oil dreſſing, or ſhammoying.

The method of bringing kid and goat's ſkins to the ſtate of pelt is nearly the ſame as for lambs, except that the liming is uſed before the hair is taken off, the hair being of no great importance, and only ſold to the plaiſterers, but the lamb's wool, which is more valuable, would be injured by the lime. Kids' ſkins will take a longer time in tanning than lambs'.

If the pelts are to be *tawed* they are then put into a ſolution of alum and ſalt in warm water, in the proportion of about three pounds of alum and four pounds of ſalt to every 120 middle-ſized ſkins, and worked about therein till they have abſorbed a ſufficient quantity. This again gives the ſkin a remarkable degree of thickneſs and toughneſs.

The ſkins are then taken out and waſhed in water, and then again put into a vat of bran and water and allowed to ferment for a time, till much of the alum and ſalt is got out and the unuſual thickening produced by it is for the moſt part reduced. They are then taken to a lofty room with a ſtove in the middle, and ſtretched on hooks and kept there till fully dry. The ſkins are then converted into a tough, flexible, and quite white leather, but to give them a gloſſy finiſh, and to take off the harſhneſs of feel ſtill remaining, they are again ſoaked in water to extract more of the ſalt, and put into a large pail containing the yolks of eggs beat up with water. Here the ſkins are trodden for a long time, by which they ſo completely imbibe the ſubſtance of the egg that the liquor above them is rendered almoſt perfectly limpid, after which they are hung up in a loſt to dry and finiſhed by gloſſing with a warm iron. There are other ſmaller manipulations, which need not be here mentioned.

The eſſential difference therefore between *tanning* and *tawing* is, that in the former caſe the pelt is combined with tan and other vegetable matter, and in the latter with ſomething that it imbibes from the alum and ſalt (poſſibly alumine) and which certainly is never again extracted by the ſubſequent waſhing and branning.

The (ſo called) Morocco leather, prepared from ſheep-ſkins chiefly, and uſed ſo largely for coach-linings, pocket-books, and the beſt kind of book-binding, is thus made. The ſkin, cleanſed and worked in the way already deſcribed, is taken from the lime-water, and the thickening thereby occaſioned is brought down, not by bran liquor as in tawing, but by a bath of dogs' or pigeons' dung diffuſed in water, where it remains till ſufficiently ſuppled, and till the lime is quite got out and it becomes a perfectly white clean pelt. If intended to be dyed red it is then ſewed up very tight in the form of a ſack with the grain ſide outwards (the dye only being required on this ſide) and is immerſed in a cochineal bath of a warmth juſt equal to what the hand can ſupport, and is worked about for a ſufficient time till it is uniformly dyed, a proceſs that demands much ſkill and experience. The ſack is then put into a large vat containing ſumach infuſed in warm water, and kept for ſome hours till it is ſufficiently tanned.

The ſkins intended to be blacked are merely ſumached without any previous dyeing. After ſome further preparation the colour of the fine red ſkins being finiſhed with a weak bath of ſaffron, the ſkins when dry are grained and poliſhed in the following way. They are ſtretched very tight upon a ſmooth inclined board, and rubbed over with a little oil to ſupple them. Thoſe intended for black leather are previouſly rubbed over with an iron liquor, by means of a ſtiff bruſh, which, uniting with the gallic acid of the ſumach, inſtantly ſtrikes a deep and uniform black. They are then rubbed by hand with a ball of glaſs cut into a polygonal ſurface, with much manual labour, which poliſhes them and makes them very firm and compact. Laſtly, the *graining* or ribbed ſurface by which this kind of leather is diſtinguiſhed is given by rubbing the leather very ſtrongly with a ball of box-wood, round the centre of which a number of ſmall equidiſtant parallel grooves are cut in, forming an equal number of narrow ridges, the friction of which gives the leather the deſired inequality of ſurface.

The common mode of *currying* leather for ſhoes, boots, &c. conſiſts in firſt ſoftening the hides as they come from the tan-pit, partly by ſoaking in water, partly by mechanical means, and then impregnating it with ſome kind of oil, by which means it is rendered much more impervious by moiſture, and proper to protect the feet from the inclemency of the ſeaſons. The proceſs in a few words is the following: the hide is firſt ſoaked thoroughly in water, then placed on a poliſhed wooden beam with the fleſh ſide outwards, and pared with a broad ſharp knife till all the inequalities are removed and it is reduced to the required thinneſs. It is then again waſhed and rubbed with a poliſhed ſtone, and while ſtill wet it is beſmeared with curriers oil, generally fiſh-oil, or a mixture of this and tallow. When hung up to dry the moiſture evaporates, and the oil, which cannot be diſſipated by mere expoſure, gradually takes the place of the moiſture, and penetrates deeply into the pores of the leather. It is then dried either in the ſun or in a ſtoved room.

Blackening the leather is alſo a part of the curriers buſineſs, which is done on the grain ſide, ſimply by rubbing with an iron liquor, but on the fleſh ſide with a mixture of lamp-black and oil.

Shammoyed leather is generally ſheep or does ſkin, prepared in the way already mentioned by dreſſing, liming, &c. and dyed if neceſſary, and then finiſhed in oil. This forms the common waſh-leather, breeches leather, &c. and is the only kind which, when dyed, will bear waſhing without the colour being materially injured.

Common boot-leather, as uſually prepared, is ſtill in ſome degree pervious to water by long expoſure to wet, and therefore fiſhermen, wild-fowl ſhooters, and thoſe whoſe employment or amuſement leads them to be long on wet ground, uſually prepare their boots with an additional dreſſing of ſome oily or reſinous matter.

The punt-ſhooters in Cambridgeſhire and the adjoining fenny parts of England, uſe the following mixture with very good effect.[h] Melt together in an earthen pipkin ½ lb. of tallow, 4 oz. of hog's lard, 2 oz. of turpentine, and as much bees-wax: make the boots thoroughly dry and warm, and rub in this mixture well with a little tow as hot as the hand can bear, or elſe hold the boots over a very gentle fire till the leather has thoroughly imbibed it. Another mixture for the ſame purpoſe, and uſed by fiſhermen, is: bees-wax, Burgundy pitch, and turpentine, of each 2 oz; tallow, 4 oz.: or ½ lb. of bees-wax, ¼ lb. of roſin, and ¼ lb. of beef-ſuet. In all caſes the boots muſt be quite dry, and the mixture applied very warm.

It only remains on the ſubject of leather to notice very ſhortly ſome of the moſt remarkable kinds of leather prepared in foreign countries, for the general methods of making leather reſemble each other very cloſely in every part of the globe.

The proceſs for the real Morocco leather, as prepared from goat-ſkins at Fez and Tetuan, is thus deſcribed by M. Brouſſonet.[e] The ſkins are firſt cleanſed, the hair taken off, limed and reduced with bran nearly in the way already deſcribed for the Engliſh Morocco leather. After coming from the bran they are thrown into a ſecond bath made of white figs, mixed with water, which is thereby rendered ſlimy and fermentable. In this bath the ſkins remain four or five days, when they are thoroughly ſalted with ſal-gem (or rock ſalt) alone (and not with ſalt and alum) after which they are fit to receive the dye, which for the red, is cochineal and alum, and for the yellow, pomegranate bark and alum. The ſkins are then tanned, dreſſed, ſuppled with a little oil, and dried.

Much excellent leather of every kind is prepared in different parts of the Ruſſian empire. The preparation of the fine Ruſſia leather, ſo well known for its quality and for its peculiar ſmell, is deſcribed at large in Mr. Tooke's

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[h] Daniel's Rural Sports.

[e] Bulletin des Sciences, Repertory, vol. xi.

" View of the Ruſſian Empire,"° to which we muſt refer the reader for the minuter particulars. In general it may be ſtated that the hides are firſt put into a weak alkaline lye to looſen the hair, and then ſcraped on a beam, then (if calves) are reduced by dogs dung, and a four oatmeal drench, then tanned with great care and frequent *handling*. The bark uſed here is ſeldom oak, but, where it can be got, the bark of the black willow, or if this cannot be had, birch-bark. They are then dyed either red or black, theſe being the two colours the moſt eſteemed. For the red the hide is firſt ſoaked in alum and then dyed with brazil wood. The black is given as uſual with an iron liquor. The leather is then ſmeared with birch tar, which gives the peculiar ſmell ſo much prized (and which when uſed for book-binding has the valuable property of protecting the book from worms), and is finiſhed by various other manipulations. The ſtreaked or barred ſurface is given to the leather by a very heavy ſteel cylinder wound round with wires.

A valuable *Saffian* or dyed *Maroquin* leather, almoſt equal to that of Turkey, is prepared largely at Aſtracan and other parts of Aſiatic Ruſſia. Only bucks and goats ſkins are uſed for this purpoſe. The favourite colours are red and yellow. The general method of preparing the pelt is the ſame as in this country for the dyed Morocco leather, that is by lime, dog's dung, and bran. Honey is alſo uſed after the branning. The honey is diſſolved in warm water, and ſome of this liquor is poured on each ſkin ſpread out on wooden trays till it has imbibed the whole of the honey, after which it is let to ferment for about three days, and then ſalted in a ſtrong brine and hung up to dry. The ſkin is then ready to receive the dye, which for red is made with cochineal and the *ſalſola ericoides*, an alkaline plant growing plentifully on the Tartarian ſalt deſarts, and the colour is finiſhed with alum. When dyed, the ſkins are tanned with ſumach. To the very fineſt reds a quantity of ſorrel is uſed with the cochineal bath, and the ſubſequent tanning is given with galls inſtead of ſumach, which renders the colour as durable as the leather itſelf. The roughneſs always obſerved on the ſurface of the ſkin is given by a heavy kind of iron rake with blunt points. The yellow ſaffians are dyed with the berries of a ſpecies of rhamnus (the Avignon berry would anſwer the ſame purpoſe, and is uſed in other countries) or with the flowers of the wild camomile.

That ſingular and valuable leather called *Shagreen* is a manufacture almoſt peculiar to Aſtrakan, where it is prepared by the Tartars and Armenians. For making ſhagreen only horſes' or aſſes' hides are taken, and it is only a ſmall part from the crupper along the back that can be uſed for this purpoſe. This is cut off immediately above the tail in a ſemicircular form, about 34 inches upon the crupper and 28 along the back. Theſe pieces are firſt ſoaked in water till the hair is looſe and is ſcraped off, and the ſkin, again ſoaked, is ſcraped ſo thin as not to exceed a wetted hog's bladder in thickneſs, and till all the extraneous matter is got out, and only a clean membranous pelt remains. The piece is then ſtretched tight on a frame, and kept occaſionally wetted that no part may ſhrink unequally. The frames are then laid on a floor with the fleſh ſide of the ſkin undermoſt, and the grain ſide is ſtrewed over with the ſmooth black hard ſeeds of the *alabuta* or *gooſe-foot* (Chenopodium album) and a felt is then laid upon them, and the ſeeds trodden in deeply into the ſoft moiſt ſkin. The uſe of this is to give the peculiar mottled ſurface for which ſhagreen is diſtinguiſhed. The frames with the ſeeds ſtill ſticking to the ſkin are then dried ſlowly in the ſhade till the ſeeds will ſhake off without any violence, and the ſkin is left a hard horny ſubſtance with the grain ſide deeply indented. It is then laid on a ſolid block covered with wool, and ſtrongly raſped with two or three iron inſtruments (the particular form of which need not be here deſcribed) till the whole of the grain ſide is ſhaved, ſo that the impreſſion of the ſeeds is very ſlight and uniform. The ſkins are then ſoftened firſt with water, and then with a warm alkaline lye, and are heaped warm and wet on each other, by which means the parts indented by the impreſſion regain much of their elaſticity, and having loſt none of their ſubſtance by paring, riſe up fully to the level of the ſhaved places, and thus form the grain or granular texture peculiar to the ſhagreen. The ſkin is then ſalted and dyed.

The beautiful green dye is given by ſoaking the inner or fleſh ſide of the ſkin with a ſaturated ſolution of ſal-ammoniac, ſtrewing it over with copper filings, rolling it up with the fleſh-ſide inwards, and preſſing each ſkin with a conſiderable weight for about twenty-four hours, in which time the ſal-ammoniac diſſolves enough of the copper to penetrate the ſkin with an agreeable ſea-green colour. This is repeated a ſecond time to give the colour more body.

° Vol. iii. p. 514.

Blue ſhagreen is dyed with indigo diſſolved in an impure ſoda by means of lime and honey. Black ſhagreen is dyed with galls and vitriol. The ſkins are finiſhed with oil or ſuet.

LEAVEN. See BREAD and FERMENTATION.

LEMONS, *Acid of*. See CITRIC ACID.

LEY or LEES, is uſually applied to any alkaline ſolution made by lixiviating pearl, or wood, or other aſhes that contain alkali.

Soap Lees is an alkali uſed by ſoap boilers, or potaſh or ſoda in ſolution, and made cauſtic by lime.

Lees of Wine are the refuſe or ſediment that depoſits from wine by ſtanding undiſturbed. See *Wine*.

LEPIDOLITE. *Lepidolith*, Wern. *Lepidolithe*, Broch.

Its colour is peach-bloſſom red paſſing into lilac-blue, alſo pearl-grey and yellowiſh-grey. It occurs in maſs, and diſſeminated in ſmall ſcales, reſembling mica. Its luſtre is gliſtening, ſomewhat paſſing into ſhining. Its fracture is fine-grained, uneven, paſſing on one hand into lamellar, and on the other hand into ſplintery. Its fragments are indeterminately angular ſharp-edged. It occurs in granular diſtinct concretions. Is tranſlucent in thin pieces; moderately hard, paſſing into ſoft; eaſily frangible. Sp. gr. 2.81—2.85.

Before the blowpipe it melts eaſily without intumeſcence into a white porous tranſparent enamel. At a high heat in a charcoal crucible it yields a pale grey, denſe ſemitranſparent hard glaſs, and loſes 17 per cent. of its weight.

Its analyſis was firſt undertaken by Klaproth, by whom it was found to contain,

Silex - - - - -	54.5
Alumine - - - - - -	38.25
Potaſh - - - - - -	4.
Oxyd of iron and manganeſe	0.75
	97.50
Loſs	2.5
	100.

A more accurate examination of this mineral was however ſubſequently undertaken by Vauqueling with the following reſult,

Silex - - - -	54.
Alumine - - -	20.
Fluat of lime - -	4.
Oxyd of manganeſe	3.
Ditto of iron - -	1.
Potaſh - - - -	18.
	100.

This mineral has hitherto been found only at Roſena, in Moravia, where it forms a thin bed in gneiſs.

LEUCITE. *Leuzit*, Wern. *Leucite*, Broch.

Its colour is yellowiſh, greyiſh, and rarely reddiſh white. It occurs in rounded or angular grains, or cryſtallized in ſolids of twenty-four faces, compoſed of two acute eight-ſided pyramids, ſet baſe to baſe, with the ſummits replaced by obtuſe four-ſided pyramids, the planes of which correſpond alternately with thoſe of the original pyramid. The cryſtals are always imbedded, and cryſtallized all round. The ſurface of the grains is rough, and for the moſt part dull; that of the cryſtals is ſmooth or ſlightly ſtreaked and gliſtening. Internally it is ſhining with a vitreous luſtre. The fracture is lamellar, paſſing to imperfectly and flat conchoidal. Its fragments are indeterminately angular ſharp edged. It varies from ſemitranſparent to opake. It is moderately hard, brittle, and eaſily frangible. Sp. gr. 2.46—2.49.

It is infuſible before the blowpipe without addition: with borax it gives a browniſh tranſparent glaſs; when expoſed to a ſtream of oxygen gas it melts eaſily into a whitiſh tranſparent glaſs.

It was firſt analyſed by Klaproth, and then by Vauquelin, with the following reſults,

	Klapr.		Vauq.
Silex -	54.	—	56.
Alumine	24.	—	20.
Potaſh -	21.	—	20.
Lime -	0	—	2
	99		98
Loſs	1		2
	100		100

Leucite occurs in lava, as well as in baſalt, and the other rocks of the lateſt trapformation. In baſalt it is for the moſt part vitreous, but in lavas it is opake and earthy. It is much leſs ſubject to decompoſition than the lavas in which it is contained, hence it occurs abundantly in looſe cryſtals in certain volcanic diſtricts: the road from Rome to Fraſcati in particular, is in many parts quite covered with them.

The lavas of Veſuvius and the baſalts of Italy abound in leucite; it alſo occurs in the baſalt and other congenerous rocks of Bohemia.

LEVIGATION is the reduction of any ſubſtance to an impalpable powder by rubbing on a flat marble, or other hard ſubſtance.

LICHEN. Several plants of this genus are known in technical chemiſtry as containing a quantity of mucilage in conſiderable purity. The extraction of this principle from the plant has lately been attempted by Lord Dundonald. See Mucilage.

LIDISCHERSTEIN. See Kieselschiefer.

LIGNEOUS ACID. See Acetous Acid (*empyreumatic*).

LIGHT. The chemical properties of light are as yet but very imperfectly known, though there is great reaſon to believe that it is an agent of capital importance in many of the great chemical changes that are going on in the viſible world, and even in the experiments of the laboratory its effects are often clearly demonſtrable.

The proceſs of rapid *combuſtion* is always attended with the evolution of light along with heat, the ſource of both of which is aſcribed by Lavoiſier to the oxygen which is known to be eſſential to combuſtion, ſo that according to this eminent philoſopher whilſt any ſubſtance is burning, the oxygen alone unites with the combuſtible ſubſtance, forming an oxyd, acid, &c. according to circumſtances, and both the light and heat which previouſly exiſted in the oxygen are now ſet at liberty and appear in the form of viſible flame.

But there are many weighty objections to this latter part of the hypotheſis, which will be found under the articles *oxygen* and *combuſtion*, ſo that many chemiſts have returned to the old opinion that the light is derived from the burning body and not from the oxygen that ſupports combuſtion, an opinion which on the whole better agrees with the obſerved phenomena.

The ſun's rays, the great ſource of light as well as heat to our world, have lately been found by Dr. Herſchel to contain, beſides all the common coloured rays, ſeparable by the priſm, a number of rays of mere heat, giving no light, ſtill leſs refrangible than the red rays of the ſpectrum, and therefore extending beyond them, and producing a greater degree of heat than any of the viſible rays. More lately it has been diſcovered, as appears both by Dr. Wollaſton[a] and Mr. Ritter,[b] that beyond the oppoſite or violet ſide of the priſm, are certain other rays, alſo inviſible, which do not affect the thermometer, but which produce ſome of the chemical effects of the viſible rays of light, particularly of the violet rays to which theſe are contiguous. Theſe therefore appear to be (if the expreſſion may be allowed) *inviſible rays of light*, or rays which, though they do not illuminate, agree in chemical properties with thoſe that do, and appear to be more than any other, ſeparate from ſolar heat.

The moſt rapid and moſt unexceptionable chemical effect of pure light hitherto diſcovered, has been the change of colour of white luna cornea to a purpliſh-brown, or ſlate colour. This change takes place without requiring the leaſt increaſe of temperature, or in any way being affected by heat or cold, and it occurs equally well in cloſe as in open veſſels, and only on the ſurface immediately expoſed to the light. This change has been ſuppoſed to depend on a deoxygenation and incipient reduction of the ſubmuriat of ſilver, but without being ſupported by any very unexceptionable experiments.

Some other anomalous chemical effects of ſolar light may be here mentioned. When the ſolutions of gold and ſilver, eſpecially the former, are placed in contact with charcoal or with any other vegetable, or any animal matter, the metal is reduced totally or partially by expoſure to the ſun's rays, and the reducing ſubſtance is generally covered with a film of gilding or ſilvering. Count Rumford however has ſhewn that this effect is not excluſively owing to light, ſince it will take place in opake veſſels when the temperature is raiſed to that of boiling water. In this way a bit of charcoal may be moſt beautifully ſpangled with gold or ſilver.

Light ſtrongly tends to decompoſe liquid oxymuriatic acid, experience having ſhewn that to preſerve it long it muſt be kept in a dark place or in opake bottles.

Light alſo renders pale nitric acid again ruddy and fuming to a certain degree, even though incloſed in veſſels hermetically ſealed.

Many of the vegetable acid ſalts, particularly the acetites, appear to be ſtrongly affected by light, to become brown, turbid, and at laſt conſiderably decompoſed.

A very great proportion of the natural dyes and colouring materials from the vegetable or animal kingdoms, have their brilliance of hue much impaired, and often entirely faded, by long expoſure to the ſun's rays, and hence the neceſſity of keeping fine tapeſtry, carpets, pictures, &c. as much as poſſible, out of the ſunſhine. The mode in which light operates here is totally unknown.

The cryſtallization of ſaline ſubſtances is remarkably affected by light, and there ſeems a ſtrong influencing affinity between light and cryſtallization, ſo that during the cryſtallization of any ſolution, if the light be only partially admitted, the cryſtals will be much more numerous on the luminous than on the dark ſide, and often the whole maſs of cryſtals will radiate towards the luminous point. Solutions of moſt of the non-deliqueſcent ſalts, ſuch as carbonat of ſoda or nitre, when put in a glaſs veſſel, and abandoned to ſpontaneous evaporation, will form arboreſcent cryſtalline pellicles, that ſlowly travel up the empty ſides of the veſſel and gradually overtop it, and proceed down on the outſide. This proceſs always begins on the ſide the neareſt to the light, and is often entirely confined to it. Acetited lime exhibits this appearance in a very beautiful manner.

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[a] Phil. Tranſ. for 1802.

[b] Phil. Journ. 8vo. vol. iv. and viii.

All ſolids and denſe liquids (not evaporable) become red and luminous at a certain temperature, which temperature is therefore deſcribed commonly as being a *red* heat. It appears however from a very ſimple and ſatisfactory experiment of Mr. T. Wedgwood,[c] that gaſes are not luminous, even at a very high heat, at which ſolids immerſed in them readily glow with a very bright red.

Whether any intenſity of heat would have this effect on gaſſes is doubtful.

Independently of the luminouſneſs produced by a high temperature, there is another kind of glow or phoſphoreſcence which a vaſt number of bodies exhibit, but in very unequal intenſity, either when the temperature is raiſed ſlightly, or by attrition, or by incipient chemical change. In the former inſtance it often appears totally unconnected with combuſtion or any other chemical phenomenon.

Some of the moſt important particulars on this curious ſubject will be mentioned under the article PHOSPHORESCENCE.

LIME. *Chaux*, Fr. *Kalk*, Germ.

Lime is an earth moderately hard, of a hot acrid taſte, ſoluble in water, though to a ſmall extent, producing nearly the ſame change on vegetable colour as the alkalies do, and ſtrongly promoting the fuſion of all earthy mixtures.

It is always prepared artificially by heating the various ſpecies of carbonats, till the carbonic acid is driven off, and it is made in very large quantities for the important purpoſes of mortars and cements of different kinds, for manure, and for other ſmaller uſes. The proceſs of lime-burning in the large way will be noticed in the following article.

For nice chemical purpoſes lime may be made by calcining in a full red heat for ſome hours either the white Carrara marble of the ſtatuaries, or oyſter-ſhells (the outer coat being firſt taken off). In both the lime is very conſiderably pure, that obtained from marble being only mixed with a ſmall portion of ſilex, and ſometimes with an atom of iron, and that from the ſhells containing only a little phoſphat of lime.

To obtain lime perfectly pure, let nitric or muriatic acid (free from iron) be quite ſaturated with fragments of white marble, leaving ſome of it for a time in the ſolution that only the lime may be taken up; add a little perfectly cauſtic ammonia to the ſolution, which will ſeparate any accidental impurity of iron or other earths but not the lime, then precipitate the lime in the ſtate of carbonat by carbonated ammonia, edulcorate the precipitate, and afterwards calcine it thoroughly. If the burning be done in an earthen crucible, too ſtrong a heat muſt not be uſed, as it would cauſe a portion of the lime to vitrify with, and adhere to the ſides of the crucible, but with a platina crucible any heat may be given.

Oyſter-ſhells will anſwer as well as marble, but the phoſphat of lime, taken up by the acid along with the lime, muſt be firſt ſeparated by pure ammonia.

The lime is known to be thoroughly calcined when, after being moiſtened with water, and reduced thereby to a ſoft pulp, it excites no efferveſcence with any acid moderately dilute. The portion that has begun to vitrify with the crucible remains hard and gritty, and will not mix with water.

The moſt known and remarkable phenomenon attending lime is the *ſlacking* with water. When a lump of well-burnt lime is dipped in water and removed after a ſecond or two, or otherwiſe wetted ſo as not to be drenched, the ſurface immediately dries, after which (a little ſooner or later according to the kind of limeſtone employed) it becomes very hot, ſwells, and cracks in every direction, and falls to pieces with a ſnapping noiſe and the evolution of a copious denſe ſteam, owing to the vaporization of the water by the intenſe heat generated. If a large quantity of very well burnt lime be ſlacked in the dark, flaſhes of light are alſo obſerved to come from it when breaking to pieces. The lime by this proceſs falls into a very fine dry impalpable powder, and when cold it will not again heat by more water.

In this ſtate it is called *ſlacked lime*, and it differs from *quick* or unſlacked lime, as appears, ſimply by containing water, and probably alſo by having parted with a large quantity of caloric, but it does not at this time contain any notable quantity of carbonic acid. Slacked lime dried at a heat of 600° contains, according to Lavoiſier, about 78 per cent. of lime and 22 of water. If ſlacked lime be diffuſed in more water it mixes uniformly with it by ſtirring, and forms a thick milky liquor, called by ſome *milk of lime*, but by repoſe all the lime falls to the bottom as a fine white ſediment, except a ſmall portion which the water diſſolves, forming *lime-water*.

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[c] Phil. Tranſ. for 1792.

Lime-water, when it has been ſome time at reſt, is always beautifully clear and tranſparent. It has a very ſtrong hot diſagreeable taſte, and changes vegetable colours nearly as the alkalies. The actual quantity of lime contained in lime-water however is very ſmall, not being more at the utmoſt than about $\frac{1}{500}$ of the ſolution, and often much leſs. When lime-water is expoſed to the air a white brittle pellicle preſently forms at the ſurface, which is the lime united with the carbonic acid, which it greedily attracts from the atmoſphere, and has thereby become inſoluble in the liquid. By degrees theſe pellicles fall down, and others ſucceed, till the whole of the lime has ſeparated and the water is rendered taſteleſs. Carbonic acid paſſed through lime-water makes it inſtantly turbid by the ſeparation of the calcareous carbonat, but this is again diſſolved, and the liquor again made perfectly tranſparent by uſing an exceſs of carbonic acid, as already explained under the article *carbonat of lime*.

Pure lime has not yet been cryſtallized artificially. On account of its very ſparing ſolubility in water, it will not cryſtallize from the hot ſolution by cooling, like the watery ſolutions of barytes and ſtrontian.

Lime by itſelf will not fuſe in a leſs heat than that given by oxygen gas before the blowpipe, but it remarkably promotes the fuſibility of all earthy and ſaline compounds, and of metallic oxyds, as already explained, under the article Glass.

Hence it is often employed as a cheap and uſeful flux in the reduction of the refractory ores.

The uſe of lime as an eſſential ingredient in mortar and other cements has already been mentioned under the articles Cements and Lutes and Cements *(Calcareous)*.

Lime has a very powerful effect on vegetable and animal ſubſtances, but eſpecially the latter, breaking down their texture, and reducing them to a ſoft incoheſive pulp. It readily unites with oils when any calcareous ſalt is added to ſoap, and the white curdy maſs thus produced conſiſts of the oil united with the lime into an inſoluble compound.

The ſalts produced by the union of lime with the different acids will be mentioned under theſe acids reſpectively.

The ſeparation of lime from magneſia in analyſis is attended with ſome difficulty, and various ways have been propoſed. The commoneſt, and that which is employed occaſionally by Klaproth, where by other experiments it is made evident that no other earth or metal is preſent, is to diſſolve both earths in ſulphuric acid, and after evaporation to thorough dryneſs, bring the mixture to a low red heat: the affuſion of *cold* water will then diſſolve out the ſulphat of magneſia with ſcarcely any portion of ſulphat of lime, after which the magneſian ſalt may be decompoſed by an alkaline carbonat and ſeparately eſtimated according to its known proportions.

Another way of eſtimating lime ſeparately is founded on the property which ammonia has (when quite cauſtic) of precipitating all the other earths and the oxyd of iron from their acid ſolutions; by which method the lime alone will be left in ſolution. But if phoſphat of lime is preſent the ammonia will precipitate it though it will not decompoſe it, which therefore may lead to an error.

Alſo if a mixture of lime and magneſia, both perfectly decarbonated, be boiled with a ſolution of carbonat of potaſh, the lime alone will become carbonated and by then thoroughly waſhing the reſidual earths, conſiſting of the carbonat of lime and the pure magneſia, and adding a ſtrong acid, the carbonic acid will be diſplaced from the carbonat of lime, and the quantity of lime may be thus eſtimated from the known proportions of this carbonat.

Mr. Tennant has adopted another method in his analyſis of the magneſian lime-ſtone. He diſſolves both earths in muriatic acid, then dries the mixture and heats for a few minutes to redneſs, by which means the muriatic acid is driven off from the magneſia but not from the lime. The quantity of magneſia is then eſtimated by the quantity of freſh muriatic acid required again to diſſolve it, whence by calculations eaſily made the reſpective quantities of the two earths may be inferred.

For the habitudes of lime when in ſolution along with *alumine*, ſee that article.

The order of the affinities of lime with the reſpective acids is as follows: the oxalic, ſulphuric, tartaric, ſuccinic, phoſphoric, nitric, muriatic, fluoric, arſenic, lactic, citric, benzoic, ſulphureous, acetic, boracic, carbonic, and pruſſic acids.

LIME *Water*, *Cream and Milk of.* (See the preceding article.)

LIMESTONE.[a] *Kalkſtein*, Wern. *Chaux Carbonatée* (in part), Hauy.

This ſpecies may be divided into the five following families.

1. *FAM.* Foliated.

1. *Subſp.* Calcareous ſpar. *Common Spar*, Kirw. *Kalkſpath*, Wern. *Spath calcaire*, Broch.

Its principal colour is white, either greyiſh, greeniſh, yellowiſh, or rarely reddiſh; the other colours that it preſents are leek and olive green; honey, ochre, wine, and wax yellow; fleſh-red, browniſh-red, and very rarely roſe-red; ſmoke-grey paſſing into black; greeniſh and yellowiſh grey, and very rarely pearl-grey and light violet-blue. On the ſurface of the lighter coloured cryſtallized varieties is often obſerved a ſegment of a circle of irideſcent colours. It occurs maſſive, in veins, diſſeminated, in globular and kidney-ſhaped pieces, in druſes, and cryſtallized. Its primitive figure is an obtuſe rhomboid, the alternate plane angles of which meaſure 101° 30′ and 78° 30′. Beſides this it preſents a vaſt number of varieties of which the following are ſome of the more remarkable.

1. A very obtuſe rhomboid, the plane angles of which meaſure 114° and 66°.

2. An acute rhomboid, the plane angles of which meaſure $75\frac{1}{2}$ and $104\frac{1}{2}$.

3. A dodecahedron with ſcalene triangular faces, compoſed of two ſix-ſided pyramids, joined baſe to baſe, ſo that the line repreſenting their common baſe forms three ſaliant and as many re-entering angles.

4. An acute rhomboid, the plane angles of which meaſure $45\frac{1}{2}$° and $134\frac{1}{2}$°.

5. A ſtill more acute rhomboid than the preceding, the plane angles of which meaſure $37\frac{1}{2}$° and $142\frac{1}{2}$°.

6. An acute, almoſt cubic, rhomboid, the plane angles of which meaſure 88° and 92°.

7. The primitive form, the two ſummits of which are intercepted by two triangular faces.

8. The ſame as var. 2. with the edges compoſing the two ſummits, replaced by narrow pentagonal planes.

9. The primitive form, with a ſtrait ſix-ſided priſm, interpoſed between the two pyramids of which it may be conſidered as compoſed: hence all the faces are rhombs.

10. The ſame as var. 3. with each ſummit intercepted by three rhombic faces, parallel to thoſe of the primitive nucleus.

11. The primitive form with a ſtrait priſm interpoſed between the two pyramids in the direction of the lateral ſolid angles of the rhomboid: hence all the faces are pentagons.

12. An acute-rhomboid compoſed of the primitive form and that of var. 5. The plane angles ſurrounding the two ſummits are equal to the acute ones of the primitive form; all the other plane angles are thoſe of var. 5.

13. A regular hexahedral priſm.

14. A rhomboid, approaching very nearly to a cube, with the two ſummits replaced by triangular planes.

15. The ſame as var. 4. with the two ſummits replaced by triangular planes.

16. The ſame as var. 1. with a ſtrait ſix-ſided priſm intervening between the two pyramids.

17. The ſame as var. 1. with an intervening priſm in the direction of the lateral ſolid angles.

18. The preceding, in which the priſm is ſo far ſuppreſſed as to form only ſix adjoining triangular faces.

19. The ſame as var. 17. except that the long ſides of the faces of the priſm, inſtead of being parallel, approach towards each other at that extremity which is terminated by a ſingle line.

20. A dodecahedron like var. 3. only more acute, each of the ſummits of which is replaced by a pyramid compoſed of three trapeziums.

21. The ſame as var. 3. the lateral ſolid angles of which are replaced by as many trapezoidal or lengthened hexagonal faces.

22. The ſame as var. 4. but bevilled on the edges contiguous to the ſummits.

23. The ſame as var. 21. with each of the ſummits replaced by three rhombic faces parallel to thoſe of the primitive nucleus.

24. The ſame as var. 17. with the extremity of the terminal pyramid replaced by a horizontal equilateral triangular plane.

25. A ſix-ſided priſm with dihedral ſummits; the ſides of the priſm are acute-angled triangles, the apexes of which are alternately directed towards each extremity.

26. A dodecahedral priſm.

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[a] Emmerling, Brochant, Hauy, Kirwan, Jameſon.

27. The ſame as var. 3. except that the lateral ſolid angles are replaced by irregular pentagons, and three of the alternate edges ſurrounding each ſummit are replaced by narrow parallelipipeds.

28. The lenticular calcareous ſpar, which is a modification of var. 11. produced by the flattening of the lateral edges, into a ſingle curved line, and the total or partial ſuppreſſion of the terminal edges, whence reſults a convex ſolid reſembling a lens.

The cryſtals of calcareous ſpar are variouſly aggregated and often deeply imbedded; hence the rhomboidal cryſtals, eſpecially the more acute ones preſent only trihedral pyramids, the three other faces that complete the rhomboid not appearing above the ſubſtance in which the cryſtals are engaged. The ſize of the cryſtals varies from $\frac{1}{10}$ of an inch or leſs to 12 or 14 inches in length; the dodecahedron var. 3. affords generally the largeſt cryſtals. The lateral planes of the cryſtals are commonly ſmooth and ſplendent.

The internal luſtre varies from nearly ſpecular to gliſtening, and is vitreous, inclining ſometimes to pearly. Its fracture is ſtrait and very rarely curved lamellar. It is eaſily diviſible in three directions, and the form of its fragments is always rhomboidal. When in maſs, calcareous ſpar occurs in large and coarſe-grained diſtinct concretions, alſo in teſtaceous, wedge-ſhaped, and diverging, priſmatic diſtinct concretions.

The tranſparency both of the maſſive and cryſtallized varieties is ſubject to much variation; in general however the cryſtals are tranſparent and ſemi-tranſparent, and the others are ſemitranſparent and tranſlucent. When tranſparent it poſſeſſes a double refraction in a remarkable degree. In hardneſs it ranks between gypſum and fluor ſpar. It is brittle, and very eaſily frangible. Sp. gr. 2.69—2.72.

Certain varieties of calcareous ſpar, eſpecially thoſe from Derbyſhire, become phoſphoreſcent when laid on a hot coal.

Calcareous ſpar diſſolves with efferveſcence in almoſt every acid, and by expoſure to the blowpipe for ſome time it is reduced to quicklime. Moſt of the varieties contain a ſmall variable proportion of iron, but the iceland ſpar, which is pureſt of all, conſiſts only of lime, carbonic acid, and water, in the following proportions:[b]

Lime - - -	55.5
Carbonic acid -	44.
Water - - -	0.5
	100.0

Calcareous ſpar occurs in veins in almoſt every kind of rock, from the oldeſt granite, even to the alluvial ſtrata. It accompanies a great variety of minerals, and is almoſt the conſtant concomitant of galena.

It is ſo generally diſtributed that a liſt of localities would be uſeleſs: the rareſt and moſt beautiful cryſtals come from Derbyſhire and Cumberland, in England; from Saxony, France, Spain, and Iceland. The double refracting Iceland ſpar may be conſidered as the pureſt form of calcareous ſpar; it appears in our cabinets in the form of rhomboidal priſms, but theſe are produced by the fracture of large dodecahedral cryſtals of var. 3.

2. *FAM.* Granularly foliated.

2. *Subſp.* Statuary marble. Granular marble. Primitive Limeſtone. *Körniger Kalkſtein*, Wern. *Pierre calcaire grenue*, Broch. *Chaux carbonatée ſaccharoide*, Hauy.

Its uſual colour is ſnow-white, yellowiſh, greyiſh and greeniſh white, rarely reddiſh-white: it alſo occurs bluiſh, greeniſh, aſh and ſmoke grey, and greyiſh-black; from reddiſh-white it paſſes into pearl-grey and fleſh-red, and from greeniſh-white into yellowiſh and olive green. Its colour is generally uniform, but ſometimes it preſents clouds, ſpots, or veins. It is always in maſs. Its luſtre varies from ſhining to glimmering, and is intermediate between pearly and vitreous. Its fracture is minutely foliated paſſing into ſplintery. Its fragments are indeterminately blunt edged. It generally occurs in granular diſtinct concretions; when theſe are very fine the fracture approaches nearly to compact. It is tranſlucent, and the leſs ſo, as it is the more loaded with colouring matter. In hardneſs it is nearly equal to the preceding; it is brittle and eaſily frangible. Sp. gr. 2.7 to 2.8.

In chemical characters it agrees with calcareous ſpar.

It occurs ſometimes in mountain maſſes, but more frequently in beds in mountains of gneiſs, and argillaceous and micaceous ſchiſtus: when in gneiſs the concretions are very diſtinct, but when it occurs in tranſition rocks the concretions are hardly viſible. It frequently contains other ſubſtances diſperſed through its ſubſtance, ſuch as mica, hornblende, actynolite, aſbeſt, quartz, ſerpentine, galena, blende, iron pyrites, and magnetic iron-ſtone.

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[b] Phillips in Phil. Mag. xiv. p. 290.

The moſt valuable variety of ſtatuary marble is the ſnow-white; that of the iſle of Paros in the Archipelago has ſupported undiminiſhed the high reputation which it appears firſt to have derived from the ſculptors of Greece, almoſt all their fineſt works having been formed of this material. Next in eſteem is the white marble of Carrara in Italy, which is employed in moſt of the finer works of modern ſtatuary. Of the coloured varieties of primitive limeſtone that of the iſland of Tiree, on the weſtern coaſt of Scotland, deſerves perhaps the higheſt place, its colour is a bright fleſh-red, beautifully relieved by interſperſed cryſtals of green hornblende; its fracture is almoſt ſplintery, and it is ſuſceptible of a high poliſh.

3. *Subſp.* Dolomite, (which ſee.)

3. *FAM.* Fibrous.

4. *Subſp.* Satin ſpar. *Common fibrous limeſtone*, Jameſon. *Gemeiner faſriger kalkſtein*, Wern.

Its colour is greyiſh, yellowiſh, or reddiſh white; it occurs in maſs. Its luſtre is between ſhining and gliſtening with a pearly or ſatiny luſtre. Its perpendicular fracture is ſtrait or waved parallel fibrous, the fibres are either fine or coarſe; the croſs fracture is compact ſplintery. Its fragments are ſplintery or flattened fibrous. It is tranſlucent, and in thin pieces is ſemitranſparent. Its hardneſs is a little inferior to that of calcareous ſpar, it is brittle, and eaſily frangible. Sp. gr. 2.7.

In its chemical characters it reſembles calcareous ſpar. Its conſtituent parts, according to Mr. Pepys,[c] are

Carbonic acid	-	47.6
Lime - -	-	50.1
Water and loſs	-	2.3
		100.0

It occurs in ſtrata from one to four inches thick, and is traverſed by veins of pyrites.

The moſt beautiful is found in Derbyſhire: it is ſuſceptible of a fine poliſh, and is employed in inlaying, and in the manufacture of ſmall ornaments in imitation of pearl.

5. *Subſp.* Stalactite or ſinter. *Kalkſinter*, Wern.

The colour of ſtalactite is ſnow-white, greyiſh, greeniſh, and yellowiſh white; alſo wax and honey yellow and yellowiſh-brown; alſo yellowiſh, browniſh, or bluiſh green, or mountain-green; ſometimes though rarely fleſh or peach-bloſſom red. The colour is either uniform or in ſtripes.

It occurs maſſive, reniform, botryoidal, tabular, ſtalactite, and tuberous. Externally it is rough and often druſy. Internally it has a glimmering pearly luſtre. Its fracture is fibrous, more or leſs divergent, often completely radiated. Its fragments are indeterminately angular, or wedge-ſhaped. It generally occurs in curved lamellar diſtinct concretions, parallel with the external ſurface. It is more or leſs tranſlucent paſſing into ſemitranſparent. Its hardneſs is equal to that of calcareous ſpar. It is brittle, and eaſily frangible.

It forms ſtalactites, and various rounded projections in the caves and hollows that ſo frequently occur in limeſtone. The Grotto of Antiparos, the Woodman's Cave in the Hartz, Caſtleton Cavern, and other caverns in Derbyſhire, Yorkſhire, &c. afford abundant ſpecimens of this mineral. Some caverns have been entirely filled by it, ſo that it is occaſionally obtained in large maſſes. In this ſtate it is called oriental alabaſter, and is much employed by the ſtatuary.

That beautiful coralloidal ſubſtance, the flos ferri, is commonly ranked among the calcareous ſtalactites. It has never been analyſed, but from its only occurring in veins of ſpathoſe iron ore, it probably contains a large proportion of carbonated iron.

4. *FAM.* Compact.

6. *Subſp.* Common limeſtone, *Gemeiner dichter kalkſtein*, Wern. *Pierre calcaire compacte commune*, Broch.

Its uſual colour is ſome ſhade of grey, either yellowiſh, bluiſh, or ſmoke-grey: from aſh-grey it paſſes into greyiſh-black, from yellowiſh-grey into yellowiſh-brown and ochre-yellow: it alſo ſometimes, though rarely occurs blood-red and fleſh-red, and greeniſh-grey. Two or more colours often exiſt in the ſame piece in the form of veins, zones, bands, ſtripes, clouds, and dots: the ſurfaces of the ſtrata and of caſual rents are often covered with black or brown arborizations. It is uſually maſſive, but alſo exhibits a variety of external ſhapes. Internally it is dull, yet often contains ſhining particles that appear to be cryſtalline laminæ. Its uſual fracture is fine ſplintery, but it paſſes into flat conchoidal, uneven, and earthy, ſometimes though rarely it is ſlaty. Its fragments are indeterminately angular, more or leſs ſharp-edged. It is tranſlucent on the edges, moderately hard, brittle, and frangible. Sp. gr. 2.6—2.7.

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[c] Phil. Mag. xii. p 367.

It diſſolves in acids with a vigorous efferveſcence, and when expoſed to the blowpipe is converted into quicklime. It is compoſed of lime and carbonic acid, with a ſmall and variable proportion of ſilex, alumine, the oxyds of iron and mangaueſe, and inflammable matter.

Limeſtone ſometimes, though rarely, occurs among the tranſition rocks, in which caſe it alternates with and reſts upon ſlate, and has a ſplintery fracture, and is for the moſt part deſtitute of the remains of organized bodies.

But the principal repoſitory for limeſtone is the claſs of ſecondary or floetz mountains. Among theſe it always occurs in ſtrata, conſtituting ſeveral diſtinct formations: the oldeſt of theſe is that which reſts upon the red ſandſtone, and bituminous marl ſlate. Some of the other formations are characterized by the ſhells with which they abound. Of theſe the leaſt recent contain ammonites, belemnites, gryphites, and turbinites, while the moſt modern contain various preſent marine ſhells and fiſh. Limeſtone ranks among the metalliferous mountains: the ores which are depoſited within it are galena and blende, more rarely fahlerz and malachite. It frequently alſo alternates with thin ſeams of hornſtone or chert, as chalk does with flint.

Limeſtone when unburnt is uſed for building and paving ſtones, and when hard and compact enough to admit of poliſhing it is employed under the name of marble, in the more ornamental parts of architecture; when deprived of its carbonic acid, or in the ſtate of quicklime, it forms the baſe of all the calcareous CEMENTS, and is largely employed by the farmer for manure, by the tanner, the ſoap-boiler, the calico-printer, &c. and by the ſmelter to facilitate the reduction of the more refractory ores.

The argillaceous limeſtones have for the moſt part a tendency to a flaty fracture, and paſs into marl; their colour is principally bluiſh-grey or reddiſh, and they are readily decompoſed by the action of the air; the mortar into which this variety of limeſtone enters poſſeſſes the quality of hardening under water, as is mentioned at large in the article CEMENT.

7. *Subſp.* Magneſian Limeſtone.[d]

This ſubſtance was confounded with common limeſtone till Mr. Tennant undertook an examination of it; and although the external diſtinctive characters between the preſent ſubſpecies and common compact limeſtone have not hitherto been laid down by any author, yet the chemical differences in the compoſition of the two clearly require their diviſion into diſtinct ſubſpecies. When deprived by heat of its carbonic acid it is much longer in reabſorbing it from the atmoſphere than common limeſtone is. Mortar made of the former and employed in the outſide of a building, in the ſpace of eight years, had recovered only 47 per cent. of the carbonic acid originally contained in the ſtone, whereas mortar of common limeſtone in a year and three quarters had regained 63 per cent. of its original amount of carbonic acid. The great length of time which this magneſian limeſtone continues cauſtic is the cauſe of a moſt important difference between this and common limeſtone with regard to their employment in agriculture: lime of the former deſcription is technically called *hot*, and when ſpread upon land in the ſame proportion as is generally practiſed with the latter, greatly impairs the fertility of the ſoil, and when uſed in a ſomewhat larger quantity entirely prevents all vegetation. The habitudes of the two ſubſpecies, with regard to their ſolution in acids, are alſo different, in the ſame manner as dolomite differs from granular marble, the magneſian limeſtone being much more ſlowly ſoluble than the other.

It occurs in ſtrata at Bredon-hill, near Derby; at Matlock in the ſame county. In the counties of Yorkſhire and Nottinghamſhire it extends from near Workſop to the vicinity of Ferrybridge, a diſtance of above thirty miles. It is alſo common in Northumberland. The Minſter and city walls of York, and Weſtminſter-hall in London, are built of it. It ſometimes though rarely contains ſhells, and appears to reſt upon ſecondary limeſtone.

According to Mr. Tennant's analyſis it contains from

20.3	to	22.5	Magneſia.
29.5	—	31.7	Lime.
47.2	—	——	Carbonic acid.
0.8	—	1.24	Clay and oxyd of iron.

5. *FAM.* Granular.

8. *Subſp.* Roeſtone. *Roogenſtein*, Wern. *Oolite*, Broch.

Its colour is hair and cheſnut brown, or yellowiſh-brown, or aſh-grey. It occurs in maſs, and is without luſtre. It is compoſed of ſmall and fine-grained globular diſtinct concretions;

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[d] Tennant in Phil. Tranſ.

hence its fracture in the great is granular, but that of each diſtinct concretion is fine ſplintery. Its fragments are indeterminately angular, blunt-edged. It is opake paſſing into tranſlucent on the edges. It is conſiderably ſofter than common limeſtone. It is brittle, and very eaſily frangible. Sp. gr. 2.45—2.55.

It occurs in beds interpoſed between ſandſtone, common limeſtone, and gypſum.

The Ketton-ſtone of England belongs to this ſubſpecies, as alſo does the Portland ſtone. It is found alſo in Sweeden, Swiſſerland, and eſpecially in the province of Thuringia, in Saxony.

It is uſed for building, and as a manure, eſpecially when broken down by expoſure to the air: but is not burnt into quicklime on account of the clay with which it is intimately mixed.

It has obtained its preſent name from the reſemblance which many of its varieties bear to the roe of fiſh; indeed it was formerly ignorantly ſuppoſed to be this very ſubſtance petrified.

9. *Subſp.* Peaſtone. *Erbſenſtein*, Wern. *Pierre de pois*, or *piſolite*, Broch.

Its uſual colour is yellowiſh-white, whence it paſſes on one hand to ſnow-white, and on the other to light yellowiſh-brown. It occurs in maſs, but when it forms the lining of cavities it is then reniform or botryoidal. Internally it is dull: its fracture is difficult to determine, but appears to be even: its fragments are indeterminately blunt-edged. It is compoſed of ſpheroidal diſtinct concretions either coarſe or ſmall, and theſe are again compoſed of thin concentric curved lamellæ. It is opake, ſoft, and eaſily frangible.

It occurs in conſiderable maſſes near the hot ſprings of Carlſbad, in Bohemia, and appears to be a depoſit from theſe fountains. The centre of each concretion is uſually a grain of ſand, but ſometimes a ſmall cavity filled with air. It is alſo ſaid to occur in Hungary, and at Perſcheeſberg in Sileſia.

On Marble.

In the language of the ſtatuary and architect all ſtones come under the name of marble that are harder than gypſum, occur in conſiderable maſſes, and are capable of a good poliſh.

Hence, not only many varieties of limeſtone, but alſo granite, porphyry, ſerpentine, and even the fine-grained baſalts, are called marble. Among mineralogiſts however the term is uſed in a more reſtricted ſenſe, being confined to thoſe varieties of dolomite, ſwineſtone, and compact and granularly foliated limeſtone that are capable of receiving a conſiderable poliſh. Of theſe calcareous marbles the moſt valuable for hardneſs, durability, and colour, are procured from Italy, from the Greek iſlands, and from Syria: the ancient Romans, when at their height of civilized luxury, alſo obtained from Numidia and other diſtricts in Africa ſome highly-eſteemed varieties of marble.

The white granularly foliated limeſtone has always been the favourite material of the ſculptors of ancient Greece and modern Europe, both on account of its pure colour, its delicate tranſlucence, and its granular texture, which renders it much more eaſy to work than compact limeſtone. Dolomite poſſeſſes ſimilar advantages, and is ſomewhat ſofter and of a finer grain: ſeveral of the ſmaller works of the Greek ſculptors are of this material. The two great ſources whence the ſtatuary marble of Europe has been procured are Paros and Carrara. The Parian marble is the pureſt, conſiſting of hardly any thing elſe than carbonat of lime; hence it is ſofter, ſomewhat more tranſparent, and of a more viſibly laminated texture than that of Carrara, which is mingled, often in conſiderable proportion, with granular quartz.

The moſt eſteemed of the architectural marbles are the following.

1. A deep blue-coloured marble, called bardiglio, from Carrara, which appears to differ only in colour from the white ſtatuary marble of the ſame place.

2. Cipolin marble, which is ſtatuary marble traverſed by veins of mica.

3. Lumachelle marble, which is a ſecondary compact limeſtone of a grey or greyiſh-brown colour, holding ſhells that ſtill retain their pearly luſtre. The fire marble of Bleyberg, in Carinthia, is the moſt valuable of this variety; the baſe is a greyiſh-brown compact limeſtone, in which are implanted ſhells of a fire colour and beautiful irideſcent luſtre.

4. Florentine marble, which is a compact very argillaceous limeſtone, of a grey colour, with deſigns of a yellowiſh-brown repreſenting architectural ruins.

5. The yellow marbles of Syria, Sienna, and Arragon.

6. The green marbles known by the names of campan, verde antiche, verde di Corſica, &c. which are mixtures of granularly foliated limeſtone, calcareous ſpar, and ſerpentine, with threads of aſbeſtos.

7. A very rich breccia, called brocatelli, con-

taining ſmall fragments of yellow-red and purple limeſtone, cemented by ſemitranſparent white calcareous ſpar.

Of the marbles that the Britiſh iſlands produce that of Tiree deſerves the firſt place; and if its colours were not apt to fade, it might rank among the moſt beautiful even of Italy. The counties of Devonſhire and Derbyſhire alſo afford ſeveral varieties of conſiderable beauty, though by no means to be compared with the moſt eſteemed of Italy and Spain.

On Limeſtone.

Although all the ſpecies with their varieties that are deſcribed in this article may, properly ſpeaking, be called limeſtone, ſince they conſiſt almoſt entirely of calcareous carbonat, and may by burning be brought to the ſtate of quicklime, yet we ſhall find in fact that the ſubſtances belonging to the family of *compact* limeſtone are the only ones that are or that can be advantageouſly employed for this purpoſe in the large way. Sometimes calcareous ſpar and, more frequently, ſtatuary marble, are uſed in the laboratory for the purpoſe of procuring a lime purer than ordinary for the purpoſes of chemiſtry. But owing to the cryſtalline texture of theſe ſubſtances, the laminæ, of which they are compoſed, part from each other during the volatilization of their carbonic acid, ſo that by the time when they are rendered thoroughly cauſtic their coheſion is deſtroyed, and they are reduced nearly to the conſiſtence of ſand, a circumſtance which muſt always prevent them from being uſed in kilns of the common conſtruction. The limekiln at preſent almoſt univerſally employed in this country is a cup-ſhaped concavity in a ſolid maſs of maſonry, open at the top, and terminated at the bottom by a grate, immediately above which is an iron door that may be opened and cloſed at pleaſure. This ſimple furnace is firſt charged with fuel (either wood or coal, but more commonly the latter), upon which is afterwards laid a ſtratum about a foot thick of limeſtone, broken into pieces not larger than the fiſt: to this ſucceeds a charge of fuel, and ſo on alternately, keeping the kiln always full. The pieces of limeſtone deſcend towards the bottom of the kiln, in proportion as the fuel is conſumed, being in the mean time kept at a pretty full red heat. At this temperature the water and carbonic acid are driven off, and by the time that the limeſtone arrives at the bottom of the kiln, which happens in about 48 hours, it is rendered perfectly cauſtic. The door above the grate is then opened, and all the lime below the next deſcending ſtratum of fuel is raked out: the remaining contents of the furnace ſink down, and a freſh charge is laid on at top. The compact limeſtone, after having undergone this proceſs, though much lighter and porous than before, ſtill retains its figure unaltered, hence it is readily ſeparable from the aſhes of the fuel, and is ſufficiently hard to be carried from place to place without falling to pieces. For ſome further remarks on the different varieties, ſee Cements calcareous.

LINSEED-OIL. See Oils, fixed.

LIQUATION, or *Eliquation.* This proceſs will be deſcribed under the article *Silver.*

LIQUOR OF FLINTS, or *Liquor ſilicum.* This term has been given to the ſolution of ſilex in a fixed alkali, and diſſolved in water. See Silex.

LIQUOR OF LIBAVIUS. See Tin.

LIQUOR (*Boyle's fuming*). See Sulphuret *of Ammonia.*

LITHARGE. See Lead.

LITHIC *Acid*, or *Uric Acid.* See Urinary Calculi.

LITHOMARGA. See Steinmark.

LITMUS or *Archil. Orſeille*, *Tourneſol*, Fr. This beautiful but periſhable dye is a violet red paſte, prepared from a ſpecies of lichen, which grows abundantly in the Canary Iſlands, in the South of France, and in ſome other parts. Many other ſpecies of lichen have alſo the property of aſſuming a beautiful purple, when prepared in the ſame manner as litmus.

Archil, by which name it is better known in commerce, is generally in the form of cakes like anotta, which are prepared largely in Holland, and in London, for the uſe of the dyers.

The Dutch proceſs has long been concealed as much as poſſible, but it is known to be effected by fermenting the moſs or lichen, and adding alkalies and urine. The following is given as the exact proceſs.[a] The lichen is firſt dried, cleanſed, and reduced to powder in a mill like the oil-mill. The powder is then thrown into a trough with one half its weight of pearl-aſh, and moiſtened with a little human urine, and allowed to ferment. This fermentation is kept up for ſome time by ſucceſſive additions of urine till the colour of the materials changes firſt to red and then to blue.

When in this ſtate it is mixed with a third of its weight of very good potaſh, and ſpread upon deep wooden trays till dry. A quantity of chalk is added at laſt, apparently with no other object than to increaſe the weight.

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[a] Journ. du Commerce, or Nich. Journ. 4to. vol. ii. p. 311.

There are ſeveral other kinds of moſs or lichen, which will aſſume by a ſimilar preparation the rich colour of the true archil, which is a crimſon tending to violet, and have occaſionally been employed for the ſame purpoſes in dyeing.

The colour of archil is readily extracted by water or by alcohol. The colour of the watery ſolution, or of any ſubſtance dyed with it, ſoon fades by expoſure to air, and hence it is uſed to give a gloſs or finiſh to the deeper and more permanent colours. It is much employed for this purpoſe in the dyeing of ſilk, ſtuffs, and ribbons.

All acids and ſalts with exceſs of acid, ſuch as alum or tartar, change the natural violet-purple of litmus to red; and this change is effected ſo readily and perfectly with a very ſmall degree of acidity, as to render this colour a valuable teſt to the chemiſt, to detect the preſence of uncombined acids. Even the carbonic acid in ſo ſmall a proportion as that in which it exiſts in the breath (or about 5 or 6 per cent. of the bulk of the air expired) may be made to change the colour of litmus infuſion, if a little of it diluted ſo that the purple-blue is ſcarcely viſible, be ſhaken in a phial containing air expoſed from the lungs. It is probable too on account of the carbonic acid from the atmoſphere, that paper or any thing elſe tinged with litmus reddens before the colour is altogether loſt.

When reddened by an acid, the blue is reſtored by an alkali, and thus litmus may be made a teſt both of acid and of alkali.

None of the known mordants appear to have any effect in rendering the dye of archil leſs periſhable, except perhaps the ſolution of tin, but this being always acid, alſo changes the colour, ſo that the fine purple-blue is equally loſt.

Marble ſoaked with litmus liquor imbibes it in ſome days, and becomes beautifully tinged in this method, and the colour will remain for a conſiderable time unimpaired.

LIVER OF ANTIMONY. See Antimony.

LIVER OF ARSENIC. See Arsenic.

LIVER OF SULPHUR. See Sulphuret.

LIXIVIUM. This term ſignifies nearly the ſame as Ley.

LOADSTONE. See Iron *(Ores of)*.

LOGWOOD, or Campeachy Wood. *Bois d'Inde*, Fr.

The tree that furniſhes this wood (the *Hæmatoxylum Campechianum)* grows to a very large ſize in various parts of the Weſt-Indies, and eſpecially on the Bay of Campeachy and along the American continent, and is imported largely into this country from Jamaica for the uſe of the dyer. It uſually comes over in moderate ſized logs, of a very dark violet-brown colour, very hard and heavy. Before it is uſed it is broken down or raſped in powerful mills into fine chips.

The taſte of logwood is mildly and agreeably aſtringent, and when long chewed it leaves a pleaſant ſweetneſs in the mouth. Both water and alcohol take up a conſiderable part of the ſoluble portion of the wood (alcohol much more than water), and thereby become tinged of a deep purple-red or brown.

Acids added to the watery decoction turn it yellow, but alkalies give a very deep purple colour, but without forming any precipitate.

Alum added to the decoction of logwood cauſes a violet precipitate or *lake*, and the ſupernatant liquor alſo remains violet, and gives a freſh portion of lake on the affuſion of an alkali.

The ſalts of iron give an inky black with all the ſolutions of logwood, under the ſame circumſtances as with galls, as explained under the article *Iron*, whence the preſence of gallic acid in logwood is proved.

The ſolutions of tin form a very fine violet or plumb colour lake with the decoction of logwood, and totally precipitate the colouring matter, ſo that the ſupernatant liquor is quite clear and colourleſs.

Logwood is uſed in dyeing, either to give its own natural purple (with ſeveral ſhades or variations according to the mordant uſed) or to heighten and improve the common black with iron and galls. It is found in this latter method to give a peculiar gloſs and luſtre which renders it a very valuable dyeing material.

LUNA CORNEA is that white curdy precipitate of muriat of ſilver which takes place when the nitrat, acetat, or any other ſoluble ſalt of ſilver comes in contact with muriatic acid, either ſingle or in any ſoluble combination. See Silver.

LUNAR CAUSTIC is nitrat of ſilver evaporated to dryneſs, melted in a heat juſt below redneſs, and immediately poured into moulds, by which it is reduced to hard black cylinders, about the ſize of common ſlate-pencils.

In this ſtate it is in frequent uſe in ſurgery as one of the beſt cauſtics hitherto known for moſt purpoſes. It differs from the cryſtallized nitrat in having loſt both its water of cryſtallization and alſo a ſmall portion of the acid.

LUTE. See the article CEMENTS and LUTES.

LYMPH. This is generally underſtood to be a clear liquid, tranſparent and colourleſs as water, which is found abundantly, but with ſeveral modifications, in various parts of the animal body. It is particularly diſtinguiſhed into *watery* and *coagulable* lymph. The former (of which the tears are an example) is little elſe than water holding in ſolution a very minute portion of ſalt, and ſtill leſs of animal matter. Coagulable lymph, which is often found in great quantity and perfection in encyſted dropſy, contains alſo a very conſiderable portion of albumen ſo as to be viſcid to the touch, and when heated to coagulate firmly like the white of egg.

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MACERATION means nearly the ſame as *Infuſion*.

MACLE. Chiaſtolith, *Karſten*. Macle baſaltique, *Hauy*.

This mineral is compoſed of two diſtinct ſubſtances, one of which is of a yellowiſh-white or dirty grey colour, the other is greyiſh-black paſſing to bluiſh-black. It occurs cryſtallized in the form of quadrilateral and nearly rectangular priſms. The ſummit of theſe priſms is always truncated, which gives an opportunity of obſerving the regular ſymmetrical diſpoſition of the two ſubſtances of which it is compoſed. The white part forms the exterior of the priſm, within which is a dark-coloured priſm, exactly parallel to that by which it is incloſed. From each of the angles of the interior priſm there proceeds a black line or thread biſecting the correſponding angle of the white priſm; ſometimes alſo at the extremity of theſe lines, and conſequently adjoining the four angles of the exterior priſm, are formed as many very thin black priſms: the black part is uſually the moſt abundant. The cryſtals are ſmall or middle-ſized, much elongated, and always imbedded. The white part is externally gliſtening; internally poſſeſſes a ſlight greaſy luſtre; the black part is at moſt ſlightly glimmering. The fracture of the white part is lamellar, often imperfectly ſo, in two directions parallel to the faces of the priſm. That of the black part is earthy. Both the one and the other are ſomewhat unctuous to the touch. It gives a white powder; is ſoft, paſſing to moderately hard, and not very brittle. Sp. gr. 2.94.

On expoſure to the blowpipe the white part of the macle gives a white ſcoria, and the black part a black glaſs.

The moſt perfect ſpecimens occur in France, near St. Brieux in Brittany, imbedded in argillaceous ſchiſtus. It is alſo found near Bareges in the Pyrennees, alſo imbedded in primitive argillaceous ſchiſtus: ſpecimens are alſo to be met with at San Jago of Compoſtella.

MADDER. *La Garance*, Fr. [a]

The plant which furniſhes this moſt valuable material in the art of dyeing (*Rubia Tinctorum*, Linn.) grows wild in moſt parts of the South of Europe, and in many parts of the Levant, and is cultivated very largely in the more northern counties, particularly in Holland, in the province of Zeeland, which has long been celebrated for producing this article in very great perfection. The madder plant grows to about three feet in height, and has a large long ſpreading fibrous root of a very deep red colour, which is the part uſed in dyeing.

The Levantine madder (called *Lizari* or *Azala*) has ſomewhat of a higher and finer colour than the Dutch, but the latter is prepared with more care in the ſubſequent drying and ſorting.

The madder roots as ſoon as they are gathered are thus prepared in Holland. They are firſt put under a ſhed, or granary, or other ſheltered place, where they remain in a free current of air for ten or twelve days till they are quite pliable, and till on ſqueezing them no juice can be preſſed out. The drying is then haſtened by removing them either into a common oven where the heat is ſlack, when the quantity of madder is but ſmall, or elſe into large ſtoved rooms built for the purpoſe, and heated with turf, with a large opening for the free exit of all the vapours within. Much care and very nice manipulation ſeems requiſite to perform this proceſs in its utmoſt perfection. When the roots are quite hard and brittle they are laid on a threſhing floor and ſlightly beaten with the flail to ſeparate the dirt and outer thin ſkin, after which they are ground in a mill and the powder ſifted, ſorted, and packed carefully in large barrels, in which ſtate it is exported, and uſed by the dyers.

The method practiſed in Turkey and Perſia to prepare the madder uſed in the beautiful

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[a] Encycl Art. Garance. N. Dict. d'Hiſtoire Naturelle.

Adrianople red (deſcribed under the article DYEING), is ſtated by Althen, an eye-witneſs to be the following: for every hundred weight of the freſh root a ſteeping liquor is prepared of two pounds of bran, and one pound of honey and alum in four gallons of water. The roots well waſhed and cleaned are then ſoaked with this liquor for two or three days, after which they are dried firſt under cover, and laſtly in the ſun. They are then ground and ſifted, the powder the laſt produced in the mill being of the beſt quality.

Good madder has a ſtrong ſmell, ſomewhat reſembling liquorice root. The powder ſhould feel ſomewhat greaſy, and clot together under the fingers, not dry and harſh. The root conſiſts viſibly of three parts. The firſt is an external thin cuticle or ſkin which is of no uſe, and is rubbed off along with the adhering dirt by the flail. This ſhews a thicker bark or cortical part, and within is the woody portion. Both of theſe are of a high red, but particularly the bark, and both are intermixed with many yellow or fawn coloured particles, which obviouſly injure the fine red colour, but no means have yet been found of ſeparating them in the root, and they are undiſtinguiſhably mixed in the grinding. When the colour is extracted in the dyeing vat the red part is found to be ſoluble to a much leſs extent in water than the yellow, and alſo is leſs readily extracted, and hence the beauty of the red is injured by long boiling or by uſing too large a quantity of the root.

Madder in the ſtate uſed by the dyers is an orange-brown powder, which is very liable to grow damp, and ſpoil by keeping in a moiſt place. In addition to what has already been mentioned on the uſe of this ſubſtance in dyeing, (*See Vol. i. p.* 378) the following experiments by Mr. Watt may be mentioned, as giving ſome information as to its chemical properties.[b]

The beſt Zealand madder ſelected for this purpoſe was of an orange-brown colour, and in moderately fine powder. With water it gave an orange-red infuſion, by maceration either with or without heat, but in the latter caſe the colour was finer. By ſlow evaporation of the infuſion or decoction in a ſhallow veſſel a pellicle gradually forms and ſinks to the bottom, and is replaced by others ſucceſſively. The extract when nearly dry is of a dingy-brown, and is only in part again ſoluble in water.

Alum added to the infuſion gives a precipitate of a very deep brown-red, and the ſupernatant liquor aſſumes a browniſh-yellow tinge.

The alkaline carbonats added to this ſupernatant liquor give a blood-red lake, miſcible with oils, but far diſtant from the beauty of the cochineal lake. If an exceſs of alkali is uſed the precipitate is rediſſolved, and the liquor becomes red. Soda does not give ſo fine a colour as potaſh. Lime precipitates a dull brown-red lake, without beauty.

The acids added to all madder infuſions turn it yellow, but form no precipitate. The natural colour is again reſtored by alkalies.

Carbonat of magneſia added to the water in which madder is infuſed turns it of a clear blood-red colour, which, however, when ſpread upon paper, becomes yellow by the ſun's rays.

Different metallic ſolutions produce the following effects: acetite of lead added to the infuſion of madder in water gives a browniſh-red precipitate: nitrat of mercury a purple brown: ſulphat of iron a beautiful clear brown: and ſulphat of mangane ſe alſo a purpliſh brown. The ſolutious of tin, as Berthollet obſerves, produce a lake void of brilliance or beauty, owing, as this chemiſt conjectures, to the precipitation of the yellow as well as the red particles of madder, ſo that this metal, which is of ſo much uſe in heightening the beauty of cochineal can hardly be uſed with any advantage for madder.

An improvement in the method of extracting the red of madder for lakes has been publiſhed by Sir H. Englefield, for which the gold medal of the Society for the Encouragement of Arts was given to the inventor.[c] It is founded on the diſcovery that the red colouring part is ſcarcely ſoluble in cold water, but in the common method of extraction is chiefly ſuſpended by means of the mucilage of the root. The principal proceſs is the following. Incloſe two ounces (troy weight) of the fineſt Dutch madder, known in commerce by the name of *crop madder*, in a bag capable of containing three or four times that quantity made of ſtrong and fine calico. Put it into a large marble mortar, and pour on it a pint of ſoft river water, preſſing the bag in every direction, and rubbing it as much as may be without danger of burſting. The water will ſoon become quite opake, and loaded with colouring matter. Pour off the water, and add another freſh pint of water, triturating it with the madder as before, and repeat the operation till the water, the laſt added, comes off but ſlightly tinged. About five pints will be required to exhauſt the colour, after which the root if taken out and dried will be found to have loſt $\frac{1}{10}$ of its weight, and with it its peculiar ſmell, and the colour will be a light nankeen or cinnamon.

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[b] Berthollet Elem. de Teinture, Vol. ii.

[c] Tranſact. of the Society, &c. Vol. xxii. p. 141.

The water loaded with the colouring matter muſt then be put into an earthen or well tinned copper veſſel (not iron) and heated till it juſt boils. Then pour it into a large baſon, and add an ounce of alum diſſolved in a pint of hot ſoft water, ſtirring the mixture carefully. Then add about $1\frac{1}{2}$ ounce of a ſaturated ſolution of carbonat of potaſh, which will excite an immediate effervеſcence, and a ſubſequent precipitation of a coloured lake. After ſtanding till cold the lake is to be collected, well waſhed with repeated quantities of warm water and gently dried. It will be then found to weigh about half an ounce, or a fourth part of the madder employed.

The above madder lake, which is very beautiful, is found by analyſis to conſiſt of more than 40 per cent. of alumine. The reſt is the colouring matter of the madder.

If the alum ſolution and the madder infuſion, alone without the alkali, be ſuffered to ſtand for a while a dull-red lake will equally precipitate, and the clear liquor will afterwards yield a beautiful ooze-red lake by alkali, but wanting ſufficient body of colour.

A lake equally good with the firſt mentioned, but of a lighter colour, will be afforded by previouſly allowing the madder and cold water to ſtand for a few days in a moderately warm place, whereby a ſlight fermentation will be induced, and a portion of the mucilage of the root deſtroyed. The proceſs is then to be continued as before.

The ſame ingenious experiments alſo ſucceeded very perfectly in obtaining a ſtill more beautiful and equally durable lake, from the freſh madder root imported from Holland, packed up in moſs.

MADREPORSTEIN. Madreporite, *Hauy*.

Its colour is greyiſh-black, or aſh-grey. It occurs in rounded maſſes from twenty to thirty pounds weight. It is compoſed of cylindrical priſmatic diſtinct concretions, either parallel or in diverging bundles. The ſurface of theſe concretions is dull; their croſs fracture preſents a concavity or convexity of a ſhining black, of which the luſtre varies from greaſy to ſilky: the longitudinal fracture is radiated and dull. It is opake, moderately hard, paſſing to ſoft, eaſily frangible. It gives a grey powder.

It diſſolves with efferveſcence in nitric acid, and contains, according to an analyſis by M. Schroll,

63	Carbonated lime
10	Alumine
13	Silex
11	Oxyd of iron
97	
3	loſs
100	

This mineral was found by the Baron Moll in the valley of Rüſbach, in Saltzburg, in detached maſſes. It ſeems nearly akin to the moſt recent ſecondary limeſtone. Its name is derived from the reſemblance in the diſpoſition of the priſms of which it is compoſed to thoſe of certain lithophytes. Some naturaliſts have ſuppoſed it to be a real petrifaction, but apparently without much reaſon, as its intrenal ſtructure is wholly different from that of the acknowledged petrifactions of this claſs.

MAGISTERY. This term appears to have been formerly nearly ſynonimous with *Precipitate*, but it is now almoſt diſuſed, except in one or two combinations, ſuch as

Magiſtery of Biſmuth, which is the white oxyd of this metal precipitated from the nitrous ſolution by the addition of water.

Magiſtery of Sulphur, which is ſulphur precipitated from its alkaline ſolution by an acid.

MAGNESIA NIGRA or MANGANESE, which ſee.

MAGNESIA ALBA, the earth *Magneſia*. *Magneſie* Fr. *Bitterſalzerde*, Germ.

This earth is procured pure, either by adding potaſh or ſoda to any acid ſolution of magneſia, or, more readily, by calcining the dry carbonat of magneſia in a full red heat for about half an hour till it gives no efferveſcence with acids.

The method of procuring the *Carbonat of Magneſia* has been deſcribed under that article. The common carbonat loſes by complete calcination about 55 per cent. of its weight, of which about 34 parts are carbonic acid and 21 are water. It ſhrinks by the proceſs to a very ſmall part of its original bulk.

Pure magneſia is a light earth of a pure and perfect whiteneſs, and abſolutely inſipid, though as commonly prepared it contains a ſmall portion of lime, to which it owes the ſlightly acrid taſte which it poſſeſſes. It does not give out any heat with water, as lime does, nor is it ſenſibly diſſolved therein. When expoſed to the air it does not *ſlack* or regain the carbonic acid which it had loſt by calcination, in which reſpect alſo it remarkably differs from lime. It readily changes the blue of violets to green, as the alkalies do, and hence magneſia has been reckoned to be one of the alkaline earths. When ſtrongly heated it becomes phoſphoreſcent.

Magneſia readily unites with ſulphur, but more feebly than the other alkaline earths. This combination, when diſſolved in water, forms a yellow liquor the *hydroſulphuret of magneſia*. (See the Article *Sulphuret*.)

All the acids diſſolve magneſia, forming ſalts moſtly very bitter and deliqueſcent, and very ſoluble in water. The fixed alkalies decompoſe theſe ſalts totally, but ammonia only partially ſeparates the earth, forming with the remainder a triple ſoluble ſalt compoſed of ammonia, magneſia, and the acid which held it in ſolution.

The ſeparation of magneſia from alumine in chemical analyſis is attended with ſome peculiar difficulties, deſcribed under the article *Alumine*. They appear to depend on a ſtrong affinity between theſe earths, which modifies and alters the uſual modes in which they are acted on by the different chemical agents when ſeparate.

Magneſia is perfectly infuſible by itſelf, the heat even of oxygen gas from the blow-pipe only producing a ſlight induration. In earthy compounds magneſia appears to have very little effect in promoting fuſion as the other alkaline earths have, but rather the contrary, ſo that the magneſian earths are found a valuable ingredient in the compoſition of the fineſt porcelain, which will bear a moſt intenſe heat without actual fuſion.

The combinations of magneſia with the different acids will be found under the reſpective acids.

The affinities of magneſia are in the following order, the oxalic, phoſphoric, ſulphuric, fluoric, arſenic, nitric, muriatic, tartaric, citric, lactic, benzoic, acetic, boracic, ſulphureous, carbonic, and pruſſic acids.

MAGNESIA NATIVE. Naturliche Talkerde, *Wern.* Magneſie native, *Broch.*

Its colour is yellowiſh-grey, with ſpots and dendritic delineations of blackiſh-brown. It occurs in maſs, tuberous or carious. Internally it is dull. Its fracture in the great is rather large and flat conchoidal, in the ſmall it is ſplintery. Its fragments are indeterminate ſharp-edged. It is opake, ſoft, and eaſy frangible. It is ſomewhat unctuous to the touch, adheres a little to the tongue, and is moderately heavy.

According to an analyſis by Dr. Mitchel and Prof. Lampadius it conſiſts of,

51	Carbonic acid
47.4	Magneſia
	A trace of iron
98.4	

It has hitherto been found only at Raubſchütz in Moravia, where it occurs in ſerpentine, accompanied by Meerſchaum.

MAGNESIA OPALINA is a preparation of ANTIMONY. (See this Article, p. 87.)

MAGNESIA VITRIOLATA. See SULPHAT of *Magneſia.*

MALACHITE. See COPPER (Ores of.)

MALACOLITE. Malacolith, *Wern.* Sahlite, *D'Andrada.*

Its colour is greyiſh-green, paſſing to pale leek green. It occurs in maſs; alſo cryſtallized in ſix-ſided priſms, with truncatures on two oppoſite edges. It is ſlightly gliſtening with a waxy luſtre. Its longitudinal fracture is lamellar in three directions. It is tranſlucent on the edges, ſcratches glaſs with difficulty, and is very ſoft to the touch, (whence its name.) Sp. gr. 3.23.

Before the blow-pipe, according to Leliévre, it is fuſible into a ſpungy glaſs, but according to D'Andrada, it is infuſible. It has been analyſed by Vauquelin, and appears to contain

53	Silex
20	Lime
19	Magneſia
3	Alumine
4	Oxyds of iron and manganeſe
99.	

This mineral was firſt met with in Sweden, in the ſilver-mines of Sahla in Weſtermanland; it has ſince been found at Buoen, near Auen in Norway. There appears to be a ſtrong analogy in many reſpects between malacolite and augite.

MALIC ACID, or *Acid of Apples*. Apfelſaure, *Germ.*

This acid was firſt diſcovered by Scheele, in the juice of unripe apples, who gave it thence the name of *Malic Acid* or *Acid of Apples*. In this fruit it is mixed with mucilage and many other ſubſtances, from which it is ſeparable by the following method indicated by this illuſtrious chemiſt. Bruiſe the fruit in a mortar and ſqueeze out the juice; ſtrain it through a cloth, ſaturate it with potaſh, and pour into the liquor a ſolution of acetited lead. A white inſoluble ſalt, the malat of lead, falls down which muſt be collected and waſhed with cold water. Then add to it ſufficient dilute ſulphuric acid, to diſplace the malic from the oxyd of lead; inſoluble ſulphat of lead will be left at the bottom, and the ſupernatant liquor will be the pure malic acid in a liquid ſtate, which is the only ſtate in which it can be exhibited, as it is uncryſtallizable, and cannot be evaporated to dryneſs without decompoſition. The preciſe quantity of ſulphuric acid neceſſary to be added may be aſcertained in the following manner: continue to pour in this acid by degrees, and with frequent ſtirring, till the liquor loſes the ſweet taſte of lead, and is purely acid: and on the other hand to detect any exceſs of ſulphuric acid add a few drops of acetited lead to a drop or two of the liquid, which will form a precipitate in any caſe, but if ſulphuric acid be preſent the precipitate will not rediſſolve in dilute nitric acid, though it will eaſily diſſolve if only malic acid be contained in it.

Malic acid has alſo been found by Vauquelin to be abundantly contained in the native juices of ſeveral ſucculent vegetables, partly uncombined, but chiefly united with lime, and the malat of lime is held in ſolution by an exceſs of its own acid, this calcareous ſalt being readily ſoluble in moſt acids that do not decompoſe it, though without this, it remains but little ſoluble in water.

The indications by which this ſalt is detected in vegetable juices are ſo accurately given by Vauquelin that we ſhall here inſert them.[a] Theſe juices are always ſenſibly acidulous ſo as to redden litmus paper: they give a copious precipitate by the carbonated or pure alkalies, and by oxalat of ammonia: ſulphuric acid when added forms an immediate depoſit of ſulphat of lime: lime-water alſo gives a precipitate, by neutralizing the exceſs of malic acid; hence not only the newly formed malat of lime is depoſited, but alſo the portion which in the natural juice was held in ſolution by exceſs of acid: laſtly acetited lead gives an abundant light flocculent precipitate, which is eaſily rediſſolved by acetous acid. This ſolubility of the malat of lead, in a weak acid, ſo much exceeds that of the ſulphat, or even muriat of this metal (which are, rigorouſly ſpeaking, ſomewhat ſoluble in acetous acid) that this teſt will eaſily diſtinguiſh the malic ſalt. There is more difficulty in drawing any ſatisfactory inference from it when certain other vegetable acids are preſent, ſuch as the citric, tartareous, and oxalic acids, all of which, as well as the malic acid, form a copious precipitate with acetite of lead, which precipitate is again ſoluble by any weak acid, nor does there appear any very ſatisfactory way of immediately deciding which of theſe vegetable acids is preſent, except that the malat of lead is much more readily ſoluble, and beſides is light and flocculent, whereas the other ſalts of this metal are heavy, and curdled in appearance. When each acid is left naked after decompoſition of the ſaturnine ſalt by ſulphuric acid, the malic acid is then diſtinguiſhable from the above-mentioned vegetable acids by remaining entirely uncryſtallizable.

Another uſeful teſt of the preſence of malat of lime in native vegetable juices, is furniſhed by the addition of alcohol, which, when this ſalt is preſent, ſeparates it in the form of a white homogeneous ſoft magma, reſembling a thick ſoup. When theſe juices are evaporated to dryneſs, they leave a yellow gloſſy matter like gum arabic, which affords a large quantity of carbonat of lime by incineration.

The malic acid is often found mixed with other acids, particularly the citric, in the ſour juices of fruits. To ſeparate them, Scheele evaporates the juice to the conſiſtence of honey, and adds alcohol, which diſſolves the two acids, and leaves a great quantity of gummy mucilage. The alcoholic ſolution is then evaporated to drive off the ſpirit, and the remaining liquor nearly ſaturated with chalk, which forms both a malat and a citrat of lime, the latter of which by further evaporation is almoſt entirely depoſited, whilſt the former remains moſtly in the clear liquor. The liquor is then mixed with alcohol (which will not take up the malat of lime, though it diſſolves the pure acid), whereby the calcareous malat is ſeparated in the ſtate of a white flocculent maſs from a ſugary matter, which the alcohol diſſolves; and the malat of lime, now pure, is decompoſed by acetited lead, and malat of lead is produced, whence the malic acid is obtained ſeparate by means of the dilute ſulphuric in the way already mentioned.

The malic acid, beſides being found native, is alſo produced during the action of nitric acid on ſugar, in the way deſcribed under the article Oxalic Acid, which latter alſo is obtained in the proceſs. The oxalic acid is cryſtallizable, and may be thus moſtly ſeparated. The liquid reſidue is malic acid mixed with any nitric acid which may have eſcaped decompoſition. A further treatment with freſh nitric acid produces a freſh crop of cryſtals of oxalic acid, whence it is probable that the malic acid is the firſt product of ſugar when acted on by nitric acid, and differs from the oxalic either in being leſs oxygenated, or perhaps from being combined with a quantity of ſugar yet unaltered, to which its uncryſtallizable nature may be owing.

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[a] An. de Chin. tom. xxxiv. & xxxv.

The malic acid, in this caſe, may be ſeparated with tolerable accuracy from the oxalic and nitric in the following way: add lime-water as long as any precipitate takes place, which will be chiefly oxalat of lime, and thus nearly all the oxalic acid will be ſeparated: then ſaturate the clear liquor with chalk, which will therefore produce the nitrat and malat of lime: add alcohol, which will diſſolve the nitrat of lime and a ſaccharine matter exiſting in the liquor, and the malat of lime remaining may then be further treated with acetited lead and ſulphuric acid, as above deſcribed.

Or if the mother-liquor remaining after the oxalic acid has firſt been ſeparated by cryſtallization be expoſed to a moderate froſt, the watery part alone will congeal, after which an intenſe artificial cold of about 7° will cauſe the malic acid to cryſtallize,[a] and theſe cryſtals being picked out and ſet to drain will ſoon again liquefy as the temperature riſes, and the liquor will be malic acid in very great purity.

The pure malic acid has been but little examined. It is uncryſtallizable except in intenſe cold as juſt mentioned, but when ſlowly dried it forms a ſort of glutinous varniſh on the veſſel that contains it. It cannot be kept for any length of time, as it ſoon ferments, and new products, chiefly acetous and carbonic acids, are generated.

The combinations of this acid with the alkaline earthy and metallic baſes, or the *malats*, have been ſcarcely examined, except the malats of lime, and of lead, which are ſo nearly concerned in the extraction and analyſis of this acid. Of the properties of theſe ſalts nothing more need be added to what has been already mentioned. The malic acid precipitates the nitrats of mercury, lead, and ſilver,[b] in which it differs from the citric acid. The malic acid forms with magneſia a very deliqueſcent ſalt readily ſoluble in alcohol, whereas with alumine it gives a ſalt almoſt inſoluble in water or alcohol, and Mr. Chenevix has therefore ſuggeſted the uſe of this acid to perform the very difficult operation of ſeparating theſe two earths. (See ALUMINE.)

The malic acid is not applied to any uſe.

MALTHA. See BITUMEN.

MANDELSTEIN. See TRAP.

MANGANESE. *Manganeſe*, Fr. *Braunſtein*, Germ. *Manganeſium. Magneſia nigra.*

Manganeſe is a metal of an iron-grey colour, brittle, and eaſily oxydable on expoſure to the air. When in the ſtate of black oxyd it communicates to borax a red tinge, which is deſtroyed by the internal blue flame of the blowpipe, but is reſtored by the external flame or the addition of nitre.

§. 1. *Ores of Manganeſe.*[a]

Sp. 1. Grey Manganeſe.

Of this there are reckoned the four following ſubſpecies.

1. *Subſp.* Radiated grey manganeſe. *Strahliges grau braunſteinerz*, Wern. *Manganeſe gris rayonné*, Broch.

Its colour is ſteel-grey paſſing to iron-black. It occurs in maſs, diſſeminated, or cryſtallized in rhomboidal priſms, the alternate angles of which are about 100° and 80°, which priſms are again diviſible in the direction of the ſhort diagonal of the baſes. Sometimes the priſm is terminated by dihedral or tetrahedral ſummits, or the ſides of the priſm itſelf are truncated or bevilled.

This mineral alſo occurs in the form of acicular cryſtals, either diverging, radiated, or interlaced. The ſurface of the cryſtals is longitudinally ſtreaked and bright ſhining. Internally it is gliſtening or ſhining with a metallic luſtre. Its fracture is ſtrait and uſually fine ſtriated, more or leſs divergent. Its fragments are wedge-ſhaped and ſplintery. It occurs in lengthened coarſe granular diſtinct concretions. Its ſtreak is black and dull. It marks ſtrongly when rubbed; is ſoft, brittle, and eaſily frangible. Sp. gr. 3.7 to 4.7.

A ſpecimen of this mineral in large rhomboidal priſms, from Ilefield in the Hartz, was analyzed by Klaproth,[b] and afforded

90.5	Brown oxyd of manganeſe
2.25	Oxygen gas
7.	Water
99.75	
.25	Loſs
100.00	

Another ſpecimen from Moravia in ſhort diverging acicular cryſtals gave

89.	Brown oxyd of manganeſe
10.25	Oxygen gas
0.5	Water
99.75	

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[a] Orig. Communic. [b] Fourcroy. [a] Emmerling, Hauy, Brochant, Kirwan, Jameſon. [b] Analyt. Eſſ. II. p. 243.

It occurs in veins in porphyry accompanied by heavy ſpar, calcareous ſpar, and iron ochre.

It is found in England in the counties of Cornwall, Devon, Somerſet, and Derby; in Aberdeenſhire, in Scotland; in Saxony, Bohemia, Moravia, and Sileſia, in Germany; in Switzerland, the North of Italy, and France.

2. *Subſp.* Foliated grey manganeſe. *Blättriges grau braunſteinerz*, Wern. *Manganeſe gris lamelleux*, Broch.

Its colour is the ſame as the preceding. It occurs in maſs, diſſeminated, or cryſtallized in rectangular tables, which are often very ſmall, and difficultly determinable. Its fracture is foliated and delicately ſtreaked. It is more eaſily frangible than the preceding ſubſpecies, of which however it ſeems to be merely a variety. It occurs in Devonſhire, at Ilefield in the Hartz, Saxony, Bohemia, &c.

3. *Subſp.* Compact grey manganeſe. *Dichter grau braunſteinerz*, Wern. *Manganeſe gris compacté*, Broch.

Its colour is ſteel-grey paſſing into iron-black. It occurs in maſs, diſſeminated, in angular fragments, botryoidal, reniform, carious, ſtalactitic, or tubercular. Its external luſtre is caſual; internally it is gliſtening, metallic: its fracture is even, flat-conchoidal, or fine-grained uneven. Its fragments are indeterminate blunt-edged. It ſometimes preſents thick curved lamellar diſtinct concretions. It varies conſiderably in hardneſs, and equally ſo in its ſtreak, that of the harder varieties having a metallic luſtre, but that of the others being dull. It is brittle and eaſily frangible. Sp. gr. 3.7 to 4.1.

The manganeſe of Romanèche in France, firſt deſcribed by Dolomieu, belongs to this ſubſpecies; it is hard enough to ſcratch glaſs and give fire with ſteel. According to an analyſis by Vauquelin it contains

50.	Yellow oxyd of manganeſe.
33.7	Additional oxygen.
14.7	Barytes.
1.2	Silex.
0.4	Carbon.
100.0	

It is the opinion of the able chemiſt who performed this analyſis that the barytes is chemically combined with the metallic oxyd in this ore.

4. *Subſp.* Earthy grey manganeſe. *Erdiges grau braunſteinerz*, Wern. *Manganeſe gris terreux*, Broch.

Its colour varies between ſteel-grey and browniſh-black. It occurs in maſs or diſſeminated, or ſuperficial, or dendritic; it is ſometimes dull, ſometimes glimmering, with a metallic luſtre.

Its fracture when dull, or nearly ſo, is fine-grained earthy, but that of the other varieties is fine ſcaly. It ſoils ſtrongly; is very tender, ſometimes even friable; is ſomewhat meagre to the touch. Sp. gr. 2 to 3.

The gas that it yields by ignition is almoſt wholly carbonic acid. *

According to an analyſis by Klaproth it contains

68.	Brown oxyd of manganeſe.
6.5	Oxyd of iron.
1.	Carbon.
1.	Barytes.
8.	Silex.
17.5	Water.
102.0	

It occurs in Cornwall and Somerſetſhire in England; Ilmenau in Saxony; Perigueux in France, &c.

The *black wad* of Derbyſhire and Devonſhire appears to be a variety of this ſubſpecies. It poſſeſſes the ſtriking property of inflaming ſpontaneouſly when mixed with one fourth of its weight of linſeed oil and ſet in a dry warm place. According to an analyſis of this ſubſtance by Mr. Wedgwood it conſiſts of the oxyds of iron and manganeſe in nearly equal parts.

Sp. 2. Black manganeſe. *Schwarz braunſteinerz*, Wern. *Manganéſe noir*, Broch.

Its colour is between browniſh-black and dark greyiſh-black. It occurs in maſs, diſſeminated, or in very ſmall ſomewhat lengthened pyramidal octohedrons, grouped together in rows. The ſurface of the cryſtals is more or leſs ſhining; internally it has a ſlight vitreous luſtre. Its fracture is imperfectly and curved lamellar. Its ſtreak is dull, and of a reddiſh-brown; it is tender, brittle, and eaſily frangible.

It is a rare mineral, and uſually accompanies grey antimony. It has not been analyzed.

It is found at Ehrenſtoch, near Ilmenau, in Saxony; at Rabenſtein, in Bavaria; Führbach, in Salzburg; and Gora, in Weſt Gallitſia.

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* Journal des Mines, No. xix. p. 27.

Sp. 3. White manganeſe.

Its colour is ſnow-white, yellowiſh or reddiſh white. It occurs in maſs, diſſeminated, mamillated, or in imperfect flattened rhomboids, or lenticular cryſtals. Internally it is ſlightly gliſtening, with a luſtre between reſinous and vitreous; it is tranſlucent at the edges; its fracture is curved foliated. It is moderately hard. Sp. gr. 2.79.

It efferveſces with the mineral acids, and with the muriatic gives a ſmell of oxymuriatic acid; by ignition it becomes black, and then ſcarcely efferveſces with nitrous acid.

According to Kirwan it contains 37 per cent. of air, the chief of which is carbonic acid.

From an analyſis by Lampadius it conſiſts of

48.	Oxyd of manganeſe.
2.1	Oxyd of iron.
49.2	Carbonic acid.
0.9	Silex.
100.2	

This ſubſtance appears to have a ſtrong analogy with pearl ſpar.

Sp. 4. Red manganeſe. *Roth braunſtienerz*, Wern. *Manganèſe rouge*, Broch.

Its colour is light roſe-red, which by decompoſition becomes light yellowiſh-brown. It occurs in maſs and diſſeminated. Internally it is dull; its fracture is even, paſſing into flat conchoidal. Its fragments are indeterminately angular ſharp-edged. It is ſlightly tranſlucent; is hard, brittle, and eaſily frangible. Sp. gr. 3.23.

By ignition it becomes reddiſh-brown, and is infuſible before the blowpipe without addition: in a ſtream of oxygen gas it melts eaſily into a dark brown tranſlucent bead, attractable by the magnet. It ſlightly efferveſces with nitrous and muriatic acids. According to an analyſis by Ruprecht it conſiſts of

35.17	Oxyd of manganeſe.
7.14	Oxyd of iron.
55.06	Silex.
1.56	Alumine.
0.78	Water.
99.71	

It occurs at Kapnick, Offenbanya, and Nagyag, in Tranſilvania, where it ſerves as the matrix for the gold ores that are wrought at thoſe places. It was ſuppoſed by Born and other mineralogiſts to be a variety of felſpar.

Sp. 5. Sulphuret of manganeſe.[d] *Black blende* of Müller de Reichenſtein.

Its colour is between browniſh-black and iron-black: it occurs maſſive and diſſeminated: it is ſhining with a metallic luſtre. Its fracture is fine-grained uneven, paſſing into obſcurely foliated: its fragments are indeterminately angular. It is opake. It gives a dull greeniſh braſs-yellow ſtreak; it is moderately hard and eaſily frangible. Sp. gr. 3.95.

When pulverized it gives out ſulphuretted hydrogen on the addition of nitrous acid.

It has been analyzed by Klaproth, and conſiſts of

82.	Oxyd of manganeſe.
11.	Sulphur.
5.	Carbonic acid.
98.	

It occurs in veins at Szekeremb in Tranſilvania, together with the preceding ſpecies, and ſerves as a matrix for the ores of gold and tellurium.

Sp. 6. Phoſphat of manganeſe and iron.[e]

Of this mineral only the few following particulars have as yet been publiſhed.

Its colour is reddiſh-brown: its fracture is lamellar; it poſſeſſes a brilliant and ſomewhat chatoyant luſtre; when divided into thin lamellæ it is ſemitranſparent; its hardneſs is a little greater than that of glaſs, it gives a greyiſh-yellow ſtreak. Sp. gr. 3.65.

It is readily fuſible before the blowpipe into a black enamel.

According to an analyſis by Vauquelin it is compoſed of

42.	Oxyd of manganeſe.
31.	Oxyd of iron.
27.	Phoſphoric acid.
100.	

It has hitherto been found only in the vicinity of Limoges, in France, where it was at firſt miſtaken for an ore of tin.

§ 2. *Aſſay and analyſis of ores.*

The analyſis of the ores of manganeſe, though upon the whole ſufficiently ſimple, is ſubject to ſome difficulties and ambiguities, in conſequence of which chemiſts are by no means agreed, either upon the beſt mode of proceeding or upon the reſults. The ſteps in the method of analyſis that require the moſt care are thoſe that relate to the ſeparation of the oxyds of iron and manganeſe, and to the aſcertainment of the amount and purity of that portion of oxygen which is ſo looſely combined with the manganeſe as to be capable of being ſeparated by mere heat, or the action of muriatic acid.

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[d] Klapr. Analyt. Eſſ. II p. 26.

[e] Ann de Chem. tom. xli. p. 242.

We have already in the article Iron given ſome account of the methods purſued by the ableſt chemiſts, in ſeparating the mixed oxyds of iron and manganeſe, but as this is a nice matter, we ſhall take the liberty of recapitulating what we have before ſtated, and of making ſome additional obſervations.

1. The method propoſed and practiſed by Bergman[f] is the following. Having previouſly ſeparated the earthy and other ingredients, let the reſidue, conſiſting of the mixed oxyds of the two metals, be digeſted in nitric acid and boiled to dryneſs, in order to oxygenate completely both the iron and manganeſe; let ſome dilute nitric acid and a little ſugar be then added, and by cold digeſtion for a few hours the manganeſe will have diſſolved, forming a limpid nearly colourleſs fluid, while the greateſt part of the oxyd of iron will remain untouched. Let the nitrat of manganeſe thus formed be decompoſed by a carbonated alkali, and the precipitate, after waſhing, be ignited for half an hour; then let the cold digeſtion in dilute nitric acid and ſugar be again repeated, and the oxyd of iron, with the exception of a few atoms, will remain untouched, while the manganeſe is diſſolved. To this laſt ſolution, moderately diluted, add drop by drop ſome cauſtic ammonia till the commencement of precipitation; then boil the whole for a minute; after which the whole of the iron may be ſeparated by the filter or decantation, the manganeſe remaining in ſolution.

2. A ſomewhat different method was followed by Cordier and Beaunier, in their analyſes of ſeveral ſpecimens of French manganeſe.[g] Having completely oxydated by means of nitric acid the iron and manganeſe, the mixed oxyds were digeſted for ſome hours in repeated portions of boiling diſtilled vinegar; the inſoluble reſidue conſiſted of oxyd of iron holding a ſmall quantity of manganeſe, the reſt of the manganeſe (with probably a little iron) being taken up by the vinegar. This method however is more tedious, and apparently leſs accurate, than that adopted by Bergman. The following improvement upon it, firſt ſuggeſted by M. Porcell, has ſince been employed with ſucceſs by Vauquelin. The mixed oxyds, after being diſſolved in muriatic acid and precipitated by a mild alkali, are to be diſſolved in diſtilled vinegar and the whole evaporated very nearly to dryneſs; from this reſidue a freſh portion of acetous acid will take up the whole of the manganeſe, and a little of the iron. This ſecond ſolution being again evaporated to dryneſs, and treated afreſh with acetous acid, will depoſit the greateſt part of its iron; and thus by repeating the proceſs two or three times the whole of the iron may be ſeparated with great accuracy. When nothing but manganeſe remains in ſolution the liquor will be entirely colourleſs, and will give a white precipitate with pruſſiat of potaſh.

3. Mr. Kirwan[h] propoſes to ſeparate the two oxyds by boiling them in a ſtrong ſolution of cauſtic fixed alkali, which he ſays will take up the manganeſe and leave the iron. This however appears to be an overſight: for although oxyd of manganeſe is ſoluble in alkali in the *dry* way, a ſolution of the ſame has no ſolvent action whatever upon it; and, in conſequence, this very proceſs is uſed by Klaproth to ſeparate alumine from manganeſe, the former alone of theſe ſubſtances being capable of being taken up by this fluid.

4. According to Richter[i] manganeſe and iron may be ſeparated from each other by diſſolving the mixture in ſulphuric acid, and then adding a concentrated ſolution of tartrite of potaſh, both liquors being warm: by evaporating the whole gently till the ſulphat of potaſh begins to form, the tartrite of manganeſe will be entirely depoſited in a pulverulent ſtate while the iron will remain diſſolved. Klaproth however found this method ineffectual when muriatic acid was employed inſtead of ſulphuric.[k]

5. The ſolubility of pruſſiat of manganeſe in a dilute acid, and even in pure water, and the inſolubility of pruſſiat of iron in the ſame menſtrua, affords an accurate and ſatisfactory method of ſeparating theſe two metals from each other. To the compound muriatic ſolution, containing a ſlight exceſs of acid, add pruſſiat of potaſh till a white precipitate makes its appearance; then digeſt the whole for ſome time in a moderate heat, and by decantation or the filter ſeparate the blue precipitate from the ſupernatant liquor; the whole of the iron will be found in the regenerated Pruſſian blue, and the manganeſe will remain in ſolution, from which it may be procured by means of a carbonated alkali.

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[f] Opuſcula II. p. 224.

[g] Journ. des Mines, No. lviii. p. 769.

[h] Mineralog. II p. 387.

[i] Ditto, p. 461.

[k] Analyt. Eſſ. II. p. 108.

6. There is yet another method of ſeparating iron and manganeſe, which has obtained the ſanction of many able chemiſts, and when performed with care is capable of much accuracy. Having previouſly diſſolved the mixed oxyds in ſulphuric or muriatic acid, and diluted the ſolution to a conſiderable degree, add, drop by drop, ſome carbonated alkali, till the liquor begins to be permanently turbid; then boil it for a few minutes and ſeparate by the filter the brown oxyd of iron which will have been precipitated: into the clear liquor add as before a few drops of carbonated alkali till what falls down is of a pure white colour, then boil the whole and ſeparate this ſecond precipitate in the ſame manner as the firſt. By this mode three diſtinct portions will be obtained, of which the firſt precipitate is pure oxyd of iron, the ſecond is a mixture of iron and manganeſe with the latter conſiderably in exceſs, and the ſolution is muriat of manganeſe entirely free from iron. The ſecond precipitate being rediſſolved in muriatic acid and treated with carbonated alkali, as already mentioned, will be ſeparated into oxyd of iron and muriat of manganeſe with ſo much accuracy as to render it unneceſſary to carry on the proceſs further.

7. The laſt method which we ſhall mention, and which at the ſame time is the moſt recently diſcovered, the moſt accurate, and the moſt expeditious, though not ſo economical as ſome of the former, is by means of ſuccinat of ſoda or ammonia. It is thus effected.[1] Diſſolve the mixed oxyds in muriatic acid, and then by means of a cauſtic alkali bring the ſolution to a ſtate of perfect ſaturation; after this drop in ſuccinat of ſoda or ammonia as long as a precipitation takes place; ſeparate by the filter the ſuccinated iron from the clear liquor and edulcorate it by repeated ablutions of cold water: add together the waſhings and clear liquor and decompoſe the whole by cauſtic ſoda, a precipitate will fall down, which when waſhed and dried is pure oxyd of manganeſe.

Having thus ſtated the principal means of overcoming one of the difficulties in the analyſis of manganeſian ores, we proceed to ſay a few words on the method of aſcertaining the amount and purity of the looſely combined oxygen. It is to be regretted however that this (which in an economical point of view is a matter of chief importance) ſhould hitherto have received ſo little notice. The moſt obvious method of proceeding is by dry diſtillation at a red heat, in which both the gas and moiſture will be driven off, and may be collected and examined by the uſual reagents. This, however, is liable to ſome objections, and principally the two following. In the firſt place, it only ſhews the quantity of oxygen *gas* that may be procured from the manganeſe ſo examined; but as the principal employment of this metallic oxyd is in the bleacheries, where it is uſed for making oxymuriatic acid, it would be eminently ſerviceable ſo to ſtate the reſults of an analyſis as to enable the manufacturers to compare different ſpecimens of manganeſe with a view to their commercial value. For this purpoſe the oxyd of manganeſe muſt be decompoſed, not into the brown oxyd and oxygen, but into the white oxyd and oxygen: mere heat however is not capable of ſeparating more than that portion of oxygen which conſtitutes the difference between the brown and the black oxyds, whence it happens that many ſamples, which yield little or no oxygen by ſimple ignition, may yet be employed to good purpoſe in the preparation of oxymuriatic acid.

The ſecond objection is that the ſource of the carbonic acid which is commonly mixed with the oxygen thus procured, is often extremely ambiguous. The manganeſian ores frequently contain both carbon and carbonat of lime; but by a red heat not only part of the acid from the carbonat is driven off, but a portion of the oxygen of the manganeſe, as it is diſengaged, combines with the carbon, and thus alſo forms carbonic acid.

Some chemiſts, particularly Vauquelin and his pupils, in their analyſes of the ores of manganeſe, conſider the native oxyd as compoſed of the white oxyd, and a greater or leſs quantity of oxygen, but unfortunately adopt the very erroneous method of eſtimating this exceſs of oxygen merely by the loſs that appears at the end of the analyſis, whence its apparent amount is greater the more careleſsly the analyſis has been performed.

The ſubſtances that the commoner ores of manganeſe have hitherto been formed to be compoſed of, are the oxyds of manganeſe and iron, ſilex, barytes, alumine, carbonat of lime, carbon, and water. It is not improbable, that all theſe may coexiſt in the ſame ſpecimen, in which caſe the following would probably be the beſt method of performing its analyſis.

Take 400 grains previouſly reduced to a fine powder, and dried at 212° Fahr. divide the whole into two equal parts, and treat the firſt 200 grains in the following manner.

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[1] Analyt. Eſſ. II. p. 108.

(*a*) Put the ore into a ſmall retort, and pour upon it about twice its weight of moderately dilute and colourleſs nitric acid; the *carbonic acid* of the carbonat of lime will be thus diſengaged without the application of heat, and may be received in an inverted jar of lime-water; from the regenerated carbonat thus produced, its acid may be calculated according to the known proportions. When the evolution of carbonic acid ceaſes, transfer the contents of the retort into a digeſting flaſk, add a ſmall piece of ſugar, and apply a gentle heat; when the action of the acid has ceaſed, pour off the clear fluid, and digeſt the remainder with freſh nitric acid and ſugar as long as any thing ceaſes to be taken up; then mix together the nitric ſolutions and the waſhings of the undiſſolved reſidue.

(*b*) The reſidue juſt mentioned being dried at a heat below ignition and weighed, muſt be ignited in an open crucible to burn off the *carbon*, the amount of which will be indicated with ſufficient exactneſs by the difference of weight before and after ignition.

(*c*) The reſidue of *b* is to be boiled to dryneſs in a ſilver crucible with thrice its weight of liquid cauſtic ſoda; the hardened maſs is to be diſſolved in dilute muriatic acid, then evaporated nearly to dryneſs, and boiled with water; a fine white powder will remain undiſſolved, which is *ſilex*.

(*d*) Add together the nitric (*a*) and muriatic (*c*) ſolutions, and pour in liquid ammonia as long as any precipitation takes place; ſeparate the precipitate by filtration, and add the waſhings to the clear liquor.

(*e*) To the clear liquor of *d* pour in a ſlight exceſs of ſulphuric acid, and make the whole boiling hot; the precipitate being ſpeedily ſeparated by the filter and waſhed, is ſulphat of *barytes*.

(*f*) Evaporate the clear liquor of *e* to a very ſmall bulk, and mix it with cold alcohol; the reſulting precipitate is ſulphat of *lime*.

(*g*) The precipitate of *d* is now to be digeſted in cauſtic ſoda: when the action of the alkali ceaſes, pour off the liquor, edulcorate the reſidue, add the waſhings to the liquor, neutralize with muriatic acid, and then pour in carbonat of ammonia, till no further precipitation takes place. The precipitate being waſhed and ignited is *Alumine*.

(*h*) The reſidue of *g* which is inſoluble in ſoda, conſiſts of the mixed oxyds of manganeſe and iron, which may be ſeparated by any of the methods already mentioned. If that deſcribed in paragraph 6 is preferred, muriatic acid is to be added till the whole of the oxyd is taken up and then carbonated ſoda will throw down a precipitate which when ignited is pure *oxyd of iron*.

(*i*) To the muriatic ſolution of *h* add cauſtic ſoda; the precipitate thus occaſioned when waſhed and ignited in an open crucible is *brown oxyd of manganeſe*.

The component parts of the ore are now all aſcertained except the water and looſe oxygen, and in order to determine theſe we muſt have recourſe to the ſecond portion of the ore, weighing like the firſt 200 grains.

(*a*) Put the ore into a ſmall glaſs retort connected with a pneumatic mercurial apparatus, and make the bulb of the retort moderately red hot as long as any gas is diſengaged. By this means the *water* will be condenſed in the receiver, and the gas will paſs forwards into the inverted jar.

(*b*) The air thus collected being mixed with nitrous ſulphat of iron, the amount of its *oxygen* is readily aſcertained. The weight of the oxygen added to that of the brown oxyd of manganeſe gives very nearly though ſomewhat leſs than the entire weight of the manganeſe in the ſtate in which it exiſts in the ore. The *diſpoſable* oxygen, or that which may be applied to the preparation of oxymuriatic acid, is found by deducting 6 per cent. from the brown oxyd, and adding this to the weight of the gaſeous oxygen. Of the diſpoſable oxygen, 16 parts repreſent 100 of oxymuriatic acid, produced by diſtilling together the ore and common muriatic acid.

We ſhall conclude this ſection by ſtating the particulars of ſome of the moſt intereſting analyſes that have yet been publiſhed of the ores of manganeſe.

Radiated grey Manganeſe.

A cryſtallized ſpecimen of this mineral was thus analyſed by Klaproth.[m] 200 grains being pulverized were digeſted in the cold with muriatic acid; in a few hours the whole diſſolved without efferveſcence, forming a deep brown-red fluid. Being then heated a copious extrication of oxymuriatic acid gas took place; when this had ceaſed, and the liquor was diluted with water it exhibited a faint reddiſh colour, a few atoms of carbon being the only part of the ore remaining undiſſolved. The ſolution was divided into two equal parts, one of which was examined with the following reagents.

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[m] Analyt. Eſſ. II. p. 243.

Sulphuric acid produced no precipitate; therefore no barytes was preſent.

Pruſſiat of potaſh threw down a peach-coloured precipitate, therefore ſcarcely any iron was preſent.

Carbonated alkalies occaſioned a white precipitate, which retained its colour on expoſure to the air.

Cauſtic alkalies gave a brown precipitate.

Water impregnated with ſulphuretted hydrogen produced no turbidneſs or other change.

The other half of the ſolution was neutralized with carbonat of potaſh till a ſlight turbidneſs appeared; and being then boiled and filtered, a few ſcarcely perceivable brown particles of oxyd of iron were ſeparated. To the remaining fluid, carbonat of potaſh was added to full ſaturation at a boiling temperature; 136 grains of carbonated manganeſe was thus obtained, which (after ſtrong ignition) weighed 88.5 grains. This oxyd being then heated with ſtrong nitric acid and ſugar entirely diſſolved, forming a colourleſs fluid, from which, by diſtillation to perfect dryneſs, a lead-grey maſs of perfect oxyd of manganeſe with a metallic luſtre was procured.

200 grains more of the ore were heated thoroughly red in a glaſs retort connected with a pneumatic apparatus, by which means 14 grs. of water and 4.5 grs. of oxygen gas were collected, the remainder in the retort weighing 181 grs.

Hence 100 parts of the ore contain

90.5	Brown oxyd of manganeſe.
2.25	Oxygen.
7.	Water.
99.75	

Compact grey manganeſe of Romaneche.

This was analyzed by Vauquelin[*] in the following manner:

100 parts being treated by muriatic acid there remained 1.6 of a black matter; this reſidue on expoſure to the air inflamed, and left behind 1.2 of ſilex.

Sulphuric acid being added to the ſolution threw down 21 of ſulphated barytes, equivalent to 14. of barytes. From the remaining liquor carbonat of potaſh precipitated 96. of very white carbonat of manganeſe, which by ſtrong diſtillation in an earthen retort afforded 48 of a greeniſh-grey oxyd of manganeſe.

Thus there have been obtained

48.	Oxyd of manganeſe.
14.	Barytes.
1.2	Silex.
0.4	Carbon.
63.6	

The 36.4 parts requiſite to make up the original 100 is conſidered by Vauquelin as oxygen abſtracted from the ore by its ſolution in muriatic acid and the ſubſequent production of oxymuriatic acid. To this eſtimate however it may be objected, that no notice whatever is taken of the water which probably exiſted in the ore, that no allowance is made for the loſs experienced in almoſt every analyſis, and that it is contrary to Bergman's experiment which has never yet been diſputed, in which from 100 of metallic manganeſe he procured by ſolution in nitric acid and precipitation by cauſtic alkali 168 of black oxyd, according to which 48 parts even of metallic manganeſe can only take up 32 of oxygen.

Sulphuret of manganeſe.

Klaproth's analyſis of this mineral is as follows:[*] 100 grains were heated red hot in a retort connected with a mercurial pneumatic apparatus, by which 5 grains of carbonic acid and a ſcarcely perceptible quantity of moiſture were obtained. Another 100 grains were treated with moderately ſtrong nitric acid; ſulphuretted hydrogen gas immediately eſcaped with a copious efferveſcence, and the ore was diſſolved with the exception of 5.5 grs. which were ſulphur. The filtered ſolution being diluted was divided into two equal parts of which one was decompoſed by cauſtic ſoda; a white precipitate fell down which ſpeedily became brown by expoſure to air; the other half was decompoſed by carbonated ſoda, and the white precipitate hence reſulting remained unaltered in colour by drying; hence it contained no iron.

Another 100 grains was treated in the cold with dilute nitric acid; 34 grs. of ſulphuretted hydrogen eſcaped, and one grain of ſulphur remained floating in the ſolution. Carbonat of ſoda being added to the filtered ſolution, a white carbonated oxyd of manganeſe fell down, weighing 145 grs. which by ignition in a ſmall glaſs retort was reduced to 82 grs. the colour remaining unaltered. To this reſidue half its weight of ſulphur (i. e. 41 grs.) was added

[*] Journ. des Min. No. 19, p. 40.

[*] Analyt. Eſſ. II. p. 28.

and the mixture ignited in a retort; part of the ſulphur ſublimed, and there remained at the bottom a maſs weighing 98 grs. which in colour and chemical properties exactly reſembled the original ore. No other ſubſtances being detected except oxyd of mangaŋeſe, carbonic acid, and ſulphur, and the weight of the two former being aſcertained, the reſidue is to be conſidered as ſulphur, after deducting 2 per cent. for the uſual loſs in analyſes of this kind. Hence the component parts of the ore may be ſtated, as

82.	White oxyd of manganeſe.
5.	Carbonic acid.
11.	Sulphur.
98.	

It will not we truſt be conſidered as a mark of diſreſpect towards the illuſtrious author of this analyſis, if we venture to ſuggeſt a few doubts, not with regard to the experiments themſelves but the deductions from them.

The only proof of carbonic acid being contained in the ore is that it yielded carbonic acid gas on being heated; but this would have happened if only carbon and oxyd of manganeſe had been preſent; again, from the ſulphuretted *hydrogen* that was produced by the action of nitric acid on the ore it is highly probable that the manganeſe was in the metallic ſtate, or at leaſt only very ſlightly oxygenated: the eſtimated amount of the ſulphur alſo appears to be much too low; ſulphuretted hydrogen contains about 71 per cent. of ſulphur, therefore 34 grains of this gas contain 24 grains, to which is to be added one grain of ſulphur left in the nitrous ſolution after the production of the ſulphuretted hydrogen, making the whole amount of ſulphur equal to 25 grs. The 82 grs. of white oxyd are compoſed of about 66 of metal and 16 oxygen. It appears therefore more conſonant to the analyſis, and to known chemical facts, to ſtate the component parts of the ſulphuret of manganeſe, as

66.	Manganeſe.
25.	Sulphur.
9.	Carbon, oxygen, and loſs.
100.	

Phoſphat of manganeſe and iron.

It is to Vauquelin[p] that we are indebted for an analyſis of this mineral. Having previouſly aſcertained the preſence of iron and phoſphoric acid in it, he took 100 parts of the ore and boiled it with liquid potaſh to dryneſs in a ſilver crucible; the ſaline maſs hence reſulting was lixiviated with diſtilled water, and the inſoluble reſidue being edulcorated and dried had acquired a deep black colour and weighed ſomething more than the entire mineral. The watery lixivium, containing a conſiderable exceſs of alkali was ſlightly ſuperſaturated with nitric acid, and then boiled in order to expel every portion of carbonic acid that the alkali might accidentally have combined with: lime-water being now poured in, a copious white flocculent precipitate took place which was phoſphat of lime, and when well waſhed and dried weighed 60 parts, indicating 27 of phoſphoric acid.

The black part of the ore, which had been inſoluble in water, was diſſolved in diſtilled vinegar, and evaporated to dryneſs; the reſidue being treated with a freſh portion of vinegar was in part diſſolved, a conſiderable quantity however of red oxyd of iron remained untouched. By repeating the exſiccation till all the iron was depoſited, and then gently igniting the depoſit, there was procured 31 grains of oxyd of iron. The fluid now containing only acetite of manganeſe was decompoſed by cauſtic potaſh, and the precipitate after waſhing and drying weighed 42 grs. and was oxyd of manganeſe.

§. 3. *Reduction of Ores.*

As manganeſe is applied to no uſe in its metallic ſtate, there are no eſtabliſhments for the reduction of its ores in the great way; and even in the laboratory the proceſs is ſeldom performed, chiefly on account of the intenſe heat which is requiſite, and which cannot be obtained in ſmall furnaces unleſs they are peculiarly well conſtructed. The uſe of all alkaline and vitreous fluxes muſt be carefully avoided; for the affinity of theſe with the oxyd of manganeſe is ſo conſiderable as entirely to prevent its reduction where they are preſent. The only method which has been attended with any tolerable ſucceſs is the following, invented by Bergman.[q] Select a ſound and very refractory crucible and line it with charcoal, or ſtill better with a mixture of linſeed meal and water, beaten up with as much finely ſifted charcoal as it will take without loſing its tenacity, dry the crucible thoroughly, gradually increaſing the heat till the meal begins to be ſcorched; then take ſome oxyd of manganeſe (purified from all extraneous ſubſtances as deſcribed in the laſt ſection) and make it up into a ball with any kind of oil; put this into the cavity of the crucible and cover it with powdered charcoal; then lute on a pierced cover or an inverted crucible, and place it in a blaſt furnace; keep it at a moderate red heat till the jet of blue flame through the hole in the cover has ceaſed, then bring the furnace rapidly to its higheſt heat, and keep it ſo for forty minutes or three-quarters of an hour: after this let the fire go out, and when the crucible is quite cold break it up carefully and the manganeſe will be found in globules of various ſizes covered for the moſt part with a thin vitreous cruſt. It appears probable that a button might be obtained by a ſecond fuſion of theſe globules with glaſs of borax, in a crucible lined with charcoal and a little pipe-clay to prevent the flux from ſinking through the pores of the charcoal.

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[p] An. de Chem. xli. p. 242.

[q] Opuſcul. ii. p. 202.

§ 4. *Phyſicial and chemical properties of manganeſe.*[r] The colour of manganeſe is greyiſh-white with a conſiderable metallic brilliancy. Its fracture is uneven granular: its hardneſs is ſomewhat greater than that of caſt iron; and it is very brittle. Its ſp. gr. according to Bergman, is 6.85, according to Hielm is 7. In fuſibility it appears to rank between platina and iron: when pulverized it is feebly attracted by the magnet, but this is probably owing to the preſence of iron, from which it is ſeldom abſolutely free.

No other metal is ſo eaſily oxydable as this. If a globule of manganeſe be broken and expoſed to the air, the fractured ſurface almoſt immediately loſes its metallic luſtre and acquires a greyiſh tarniſh; in a few ſeconds more it becomes lilac coloured, then violet, and laſtly browniſh-black; when in this ſtate, it is friable and breaks down between the fingers into a black powder, reſembling in appearance the native grey oxyd. It is by no means however as yet at a high degree of oxydation, for when treated with dilute ſulphuric acid it gives out hydrogen gas; after a few days however of expoſure to the atmoſphere it becomes more ſaturated with oxygen and then loſes this property. When heated below ignition in contact with atmoſpheric air, nearly the ſame effect takes place as at the common temperature, only more rapidly.

Chemiſts at preſent diſtinguiſh three degrees of oxydation of this metal, each of which is characterized by a remarkable change of colour. The white oxyd contains the ſmalleſt proportion of oxygen, and the black oxyd the largeſt; the red oxyd holds an indeterminate place between the two others.

The white oxyd of manganeſe is moſt conveniently prepared by adding a carbonated alkali to muriat of manganeſe; the copious white precipitate that enſues is carbonated manganeſe, from which by gentle ignition in a ſmall glaſs retort, the water and carbonic acid is ſeparated, and the white oxyd remains behind. The proportions of the component parts of this oxyd are, according to Bergman, 80 of manganeſe and 20 of oxygen.

The red oxyd is obtained by mixing two parts of ſulphuric acid with one part of black oxyd of manganeſe and a little water, and boiling the maſs to dryneſs: water digeſted upon the reſiduum acquires a beautiful crimſon colour, from taking up the red ſulphat of manganeſe thus produced. If now to this red fluid a few drops of carbonated alkali be added, the liquor becomes colourleſs and a little red oxyd is precipitated, which however turns brown before it can be dried.

No proper analyſis has been made of this oxyd, but it is ſuppoſed to be manganeſe with a larger proportion of oxygen than is contained in the white oxyd.

The black oxyd is thus prepared by Bergman. To a ſolution of the ſulphat or any other of the ſalts of manganeſe is added ſome cauſtic alkali; a brown precipitate immediately falls down, which when waſhed and dried in an open crucible, at a heat below ignition, acquires a deep browniſh-black. From 100 parts of metallic manganeſe thus treated, Bergman obtained 168 of black oxyd, according to which its conſtituent proportions are 60 of metal to 40 of oxygen.

The exiſtence of the three oxyds of manganeſe juſt mentioned was firſt aſcertained by Bergman, and ſucceeding chemiſts, acquieſcing in the experiments and deductions of this able philoſopher, have done little either to confirm or correct them; it appears to us, however, that the following circumſtances reſpecting the oxyds of this metal taken notice of by Bergman himſelf, by Scheele, Klaproth, and others, are not perfectly conſiſtent with the received opinions on this ſubject. Regulus of manganeſe by expoſure to the air for two or three days falls into a pulverulent oxyd of a deep black colour; but that this ſubſtance is very different from the perfect black oxyd is

[r] Scheele's Eſſ. p. 57. Opuſcul.

manifeſt from this, that when digeſted with dilute ſulphuric acid it forms a colourleſs ſolution, and at the ſame time gives out hydrogen gas. Klaproth alſo obſerves of this ſame oxyd, that when kept in the air it exhales for ſeveral days a ſtrong odour of hydrogen, proceeding no doubt from the decompoſition of the moiſture of the atmoſphere. Here then appears to be a black, or rather as we believe a *blue* oxyd of mangaueſe, combined with ſo ſmall a portion of oxygen as to be ſtill capable of decompoſing water, and probably much leſs oxygenated than the white oxyd. It is this oxyd alone which ſeems capable of uniting with the fixed alkalies by fuſion; for if we melt together pearlaſh and the perfect black oxyd of manganeſe the reſult is a ſaline maſs of a blue colour (but green if any yellow oxyd of iron is preſent) and forming with water a ſolution of the ſame tinge. If this ſolution be largely diluted with water the manganeſe paſſes in a ſhort time to the ſtate of red oxyd, and is gradually precipitated: this may ariſe either from the atmoſpheric air contained in the water or from a decompoſition of part of the water itſelf. The ſame effect happens, but more ſlowly, if the ſolution is expoſed to the air, probably by the combined action of the carbonic acid and the oxygen of the atmoſphere, the former uniting with the alkali and the latter with the metallic oxyd. The action of any of the more active acids, for example the ſulphuric or muriatic, as might be expected, is ſimilar but more ſpeedy, with only this difference, that if more acid be added than is neceſſary to ſaturate the alkali, the exceſs of acid diſſolves the manganeſe as it paſſes to the ſtate of white oxyd; forming with it a colourleſs permanent ſolution. It is the blue oxyd of manganeſe alone that ſeems undecompoſable by mere heat, as is manifeſt from a well-known fact firſt obſerved by Rinman, namely, that if the common black oxyd of manganeſe is expoſed for ſeveral hours to a white heat, the reſult is a hardened maſs of a green colour; but as the only colouring materials in the common black manganeſe are iron and manganeſe, it is obvious that the yellow oxyd of iron muſt be mixed with the blue oxyd of manganeſe. Another characteriſtic of this oxyd is, that it is incapable of combining with acids till by the abſorption of a freſh portion of oxygen, it has paſſed to the ſtate of the white oxyd; as is manifeſt by its forming with them not a blue but a colourleſs ſolution.

The white oxyd of manganeſe may be exhibited in the leaſt unequivocal manner by adding cauſtic alkali to a *concentrated* ſolution of the ſulphat or muriat, but if a diluted ſolution of the metallic ſalt is employed, the precipitate will be a duſky brown, probably in conſequence of the atmoſpheric air mixed with the diluting water. Bergman's method of preparing the black oxyd in the higheſt ſtate of oxydation has been already mentioned, but from the uncertainty attending the proceſs it can hardly be conſidered as an unobjectionable baſis on which to found minute calculations. The mode adopted by Klaproth ſeems much more ſatisfactory. Having diſſolved carbonated manganeſe in nitric acid to ſaturation and diſtilled the mixture to dryneſs, the whole of the acid was thus ſeparated, and there remained in the retort a grey oxyd of a ſparkling metallic luſtre, exactly ſimilar in external appearance to the native grey oxyd, and from the circumſtances of its formation quite ſaturated with oxygen. If the native cryſtallized grey manganeſe is gently ignited till it ceaſes to give out oxygen gas, the reſult is a black powder which ſeems to be extremely ſimilar to the black oxyd of Bergman; and if this is really the caſe the black oxyd muſt be conſidered as eſſentially different from the grey, and ranking after it in the order of oxygenation.

Much yet remains to be inveſtigated before the oxyds of manganeſe are fully underſtood; the following characters, however, appear to diſtinguiſh them ſufficiently from one another. The blue oxyd contains the ſmalleſt proportion of oxygen: it is ſoluble in fixed alkalies but not in acids.

The white oxyd is the next in order; it combines with acids, forming colourleſs ſalts; it may be converted by ignition in a covered crucible to the ſtate of red oxyd, or to black oxyd by gentle calcination in an open veſſel.

The red oxyd is ſoluble in the ſulphuric and muriatic acids, and communicates its own colour to the ſolution, which may be deſtroyed by the addition of ſugar and other carbonaceous ſubſtances: during its ſolution in the abovementioned acids it gives out no gas.

The black oxyd is of a browniſh-black colour; by digeſtion in cold muriatic acid it forms a deep reddiſh-brown ſolution, from which water throws down the whole of the colouring matter; the muriatic ſolution being heated gives out oxymuriatic acid, and the metal paſſes to the ſtate of red oxyd. By gentle ignition it gives out little if any oxygen.

The grey oxyd is diſtinguiſhable by its metallic luſtre, by the quantity of oxygen gas which it gives out on ignition, by its little ſolubility in cold muriatic acid, and by the copious production of oxymuriatic acid from theſe ingredients when heated.

The recently precipitated oxyds of manganeſe eaſily paſs by expoſure to the air from a low to a higher ſtate of oxydation. It has alſo been aſſerted by ſome chemiſts that the native grey manganeſe, after its looſely combined oxygen has been driven off by ignition, is capable of again ſupplying itſelf with a freſh portion, if made up into a paſte with water and expoſed for ſome weeks to the air: this, however, if we may judge from our own experience and the concurring teſtimony of Dr. Thomſon, appears to be a miſtake.

We now proceed to conſider the action of acids[a] on manganeſe and its oxyds.

Sulphat of manganeſe may be prepared in various ways. If metallic manganeſe and diluted ſulphuric acid, are mixed together, a copious efferveſcence of hydrogen gas takes place, and the metal is rapidly diſſolved, leaving behind a black ſpungy matter, which appears to be carburet of iron. The filtered liquor is perfectly colourleſs, and affords by evaporation and cooling, large oblique four-ſided priſms, which are ſulphat of manganeſe. The white oxyd, either ſimple or carbonated, may be ſubſtituted for the metal with the ſame reſult, except that with the former the combination takes place without the extrication of gas, and that with the latter carbonic acid is given out. If the red or either of the more perfect oxyds of manganeſe be employed, it is neceſſary to add to the mixture a little ſugar or other carbonaceous ſubſtance to engage the exceſs of oxygen, and to apply a boiling heat. Finally, ſulphat of manganeſe may be prepared by putting ſome black oxyd and water into a Woulfe's apparatus, and throwing in ſulphureous acid gas; the black colour of the oxyd diſappears by degrees in conſequence of a portion of its oxygen being expended in converting the ſulphureous to ſulphuric acid, which acid, as ſoon as it is formed diſſolves the manganeſe now reduced to the ſtate of white oxyd, and the reſult is ſulphat of manganeſe; no gas is diſengaged during the whole of this proceſs. This ſalt readily cryſtallizes, as we have already mentioned, in oblique priſms; it has an intenſely bitter taſte, is decompoſable with precipitation of its oxyd by the cauſtic or carbonated alkalies. By dry diſtillation at a red heat the acid is decompoſed, ſulphureous acid gas paſſes over, and the manganeſe in the ſtate of black oxyd remains behind in the retort.

In the preceding, which is the colourleſs ſulphat, the manganeſe exiſts in the ſtate of white oxyd, but it may alſo combine with ſulphuric acid in the ſtate of red oxyd, forming the *red ſulphat of manganeſe*. This ſalt is prepared by mixing together equal parts of ſulphuric acid and black oxyd, and heating the maſs in a retort; oxygen gas and a little ſulphuric acid paſs over, and the dark colour of the mixture diſappears; the retort being now withdrawn, and water being added to the ſaline maſs which it contains, a violent heat is produced, and a crimſon liquor is obtained, which is the red ſulphat. By gradual evaporation it is reduced to a ſyrupy conſiſtence, and, by carrying on the proceſs farther, to a ſaline maſs; but it refuſes to ſhoot into regular cryſtals. A large quantity of water partially decompoſes it, red oxyd being precipitated; with the fixed alkalies alſo it yields a red depoſit, which ſhortly becomes brown and then black. By digeſtion with ſugar it becomes colourleſs, and paſſes to the ſtate of common ſulphat.

Nitric acid, whether colourleſs or fuming, acts vigorouſly on reguline manganeſe and diſſolves it, nitrous gas being given out: the ſolution containing *nitrat of manganeſe* is as limpid and colourleſs as water. Pure nitric acid has no action on the black oxyd; but when highly charged with nitrous gas it takes it up without any difficulty, the black colour of the oxyd and the orange of the acid equally diſappearing, in conſequence of part of the oxygen of the metal having been transferred to the acid. Hence colourleſs nitric acid may be made to act on the black oxyd by the help of ſugar or any ſimilar ſubſtance, carbonic acid being at the ſame time generated. Nitrat of manganeſe is deliqueſcent and uncryſtallizable.

Muriatic acid diſſolves reguline manganeſe, hydrogen gas being given out, and the ſolution is clear and colourleſs. When digeſted on the white oxyd it alſo forms a ſimilar colourleſs *muriat of manganeſe*. If muriatic acid is boiled on the black oxyd, part of the acid becomes converted into oxymuriatic gas at the expence of the oxyd, while the remainder of the acid diſſolves the manganeſe now converted into the white oxyd. If muriatic acid and the black oxyd be digeſted together for a few hours *in the cold*, no oxymuriatic acid is extricated, the ſolution is of a reddiſh-brown colour, and probably conſiſts of a mixture of muriatic and oxymuriatic acids combined with the red oxyd. The ſimple addition of water throws down a red precipitate, and uſually diſcharges the whole colour from the ſolution. By ebullition oxymuriatic acid is ſet at liberty, and the ſolution becomes much lighter, ſtill however retaining a faint reddiſh tinge. Reguline manganeſe, when pulverized and thrown into a vial of oxymuriatic acid gas undergoes inflammation, and is converted into the white oxyd.

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[a] Scheele's Eſſ. p. 68. Bergman Opuſcul. II. p. 210.

Both the regulus and oxyds of manganeſe are ſoluble in water highly impregnated with carbonic acid; when the former is made uſe of an odour like burning fat is perceivable, owing probably to the decompoſition of water and conſequent extrication of hydrogen gas. When the ſolution is expoſed to the air, part of the carbonic acid eſcapes and inſoluble carbonat of manganeſe is ſeparated in the form of a thin white pellicle.

The fluoric, boracic, and phoſphoric acids, exert but little direct action on manganeſe and its oxyds, but by adding the neutral ſalts of theſe acids to the ſulphat or muriat of manganeſe, a white and little ſoluble precipitate falls down, conſiſting of oxyd of manganeſe combined with the added acid.

Acetic acid by long digeſtion becomes ſaturated with oxyd of manganeſe, whether the metal or any of its oxyds are made uſe of; it does not cryſtallize on evaporation, but affords a deliqueſcent maſs. But the moſt expeditious way of ſaturating acetic acid with manganeſe is to digeſt the acid upon the recently precipitated carbonat as long as any gas is diſengaged.

Citric acid by digeſtion in the cold with the black oxyd of manganeſe, takes up a part and becomes itſelf of a brown colour; if this ſolution is then expoſed to heat an effervefcence enſues, occaſioned by the eſcape of carbonic acid, and the fluid becomes colourleſs.

Tartareous acid acts preciſely in the ſame manner as the preceding.

Oxalic acid diſſolves the black oxyd of manganeſe with effervefcence, and the ſolution when ſaturated depoſits a white cryſtalline powder, which is oxalat of manganeſe.

The action of the other acids on manganeſe has been but little aſcertained; all that we know is that they may be formed by digeſtion with the recently precipitated carbonat of manganeſe, the carbonic acid being ſeparated in the ſtate of gas.

The action of the fixed alkalies on the oxyds of manganeſe has already been deſcribed; it only remains to remark in addition, that if to the blue or green maſs produced by the fuſion of fixed alkali and oxyd of manganeſe there be added a little charcoal-powder, and the whole be expoſed to a melting-heat, a ſlight effervefcence in a ſhort time takes place, and the colour gradually changes to yellowiſh-white.

Ammonia by expoſure to black oxyd of manganeſe at a red heat is entirely decompoſed, its hydrogen uniting with part of the oxygen forms water, and the azot, its other element, by combination with a further portion of oxygen, produces nitrous acid, as may be ſeen more at large under the article Ammonia.

Nitre and the black oxyd being diſtilled together, nitrous acid and oxygen gas paſs over; what remains in the retort is a blue maſs, conſiſting of oxyd of manganeſe and potaſh.

Muriat of ammonia, by dry diſtillation with the black oxyd, gives out its ammonia, of which part paſſes off undecompoſed, but the reſidue, with the liberated oxygen of the manganeſe, forms water and azot.

The black oxyd, when fuſed with borax or any of the vitreſcent mixtures, communicates to the maſs an amethyſt-red colour which is diſcharged by charcoal or any other deoxygenating ſubſtance and reſtored by nitre. For a full account of the curious and intricate phenomena, which it exhibits when fuſed with glaſs, ſee that article.

Sulphur, according to Bergman, appears to have no action on reguline manganeſe. But if the black oxyd be ignited in a retort with half its weight of ſulphur, there comes over a quantity of ſulphureous acid gas, part of the ſulphur ſublimes, and there remains in the bulb of the retort a yellowiſh-green maſs, equal in weight to the oxyd employed and nearly half of the ſulphur. The manganeſe in this ſulphuret ſeems to be very nearly if not quite in the reguline ſtate; for when digeſted with muriatic or dilute ſulphuric or nitric acids, ſulphuretted hydrogen gas is liberated, the manganeſe is diſſolved, and a few grains of ſulphur alone remain in the fluid. By calcination in an open veſſel the ſulphuret is more or leſs decompoſed, part of its ſulphur eſcapes, and the reſidual maſs acquires a brown colour; if in this ſtate it is lixiviated with water a conſiderable portion diſſolves, and the fluid by evaporation and cooling depoſits cryſtals of ſulphated manganeſe: the inſoluble reſidue, by the addition of a little ſulphur and ſubſequent calcination, may be wholly converted into ſulphat.

The alkaline hydroſulphurets and hydroguretted ſulphurets ſeparate the oxyd of manganeſe from its acid ſolutions in the form of a white powder, the properties of which, however, have not been examined.

Phoſphuret of manganeſe has only been deſcribed by Pelletier.[b] If equal parts of vitreous phoſphoric acid and reguline manganeſe, together with charcoal equal in weight to $\frac{1}{15}$ of the other two ingredients, are accurately mixed in a mortar, and afterwards expoſed to a ſtrong heat in a covered crucible, the reſult will be a button of a white colour and metallic luſtre; hard, brittle, of a granular fracture, permanent in the air, and much more eaſily fuſible than the pure regulus. By fuſion before the blowpipe the phoſphorus burns out, and the metal is converted to a black oxyd.

Oxyd of manganeſe and the expreſſed oils exert a conſiderable action on each other. If one part of finely pulverized black oxyd and four parts of olive oil are digeſted together, when the mixture begins to get moderately warm, a violent efferveſcence takes place, owing to the extrication of carbonic acid, and when this ceaſes the manganeſe is found to be entirely diſſolved in the oil, which, when cold, acquires the conſiſtence of ſalve.

The alloys of manganeſe are of little importance, and have not yet been ſubjected to much chemical inveſtigation. For its alloys with gold, lead, copper, and iron, ſee the accounts of thoſe metals reſpectively.

If white arſenic and oxyd of manganeſe are heated together, the former is volatilized without at all combining with the latter; but if arſeniat of potaſh and any of the ſalts of manganeſe are mixed together, a precipitate of arſeniat of manganeſe is thrown down; this being mixed with a little charcoal and heated in a covered crucible, runs down into a dark-coloured eaſily fuſible metallic button, from which, by continued heat in an open veſſel, the arſenic is almoſt entirely volatilized, leaving the manganeſe behind in the ſtate of black oxyd.

The only uſe of manganeſe is in the ſtate of black oxyd. It is employed in the laboratory as the cheapeſt and moſt convenient material from which to procure oxygen gas. All the oxymuriatic acid conſumed in the bleacheries of Britain, France, and Germany, is prepared from manganeſe and the uſual materials of muriatic acid. Finally it is largely employed by the glaſs-makers, both as a colouring material and for the purpoſe of deſtroying the colour of the finer kinds of glaſſes; hence its common appellation of *glaſs ſoap*. It may be remarked by the bye that this latter application of manganeſe to the purpoſes of art is by far the moſt ancient, it being diſtinctly mentioned by Pliny in his Natural Hiſtory, whereas the others do not date further back than the commencement of pneumatic chemiſtry.

MANHEIM GOLD. See COPPER *(Alloys of)*, p. 347.

MARBLE. See LIMESTONE.

MARCASITE. See ARSENICAL Pyrites, p. 93.

MARINE ACID. See MURIATIC ACID.

MARL.

Of this mineral there are the two following ſubſpecies.

1. *Subſp.* Earthy marl. *Mergel erde*, Wern. *Marne terreuſe*, Broch.

Its uſual colour is yellowiſh-grey, paſſing ſometimes to Iſabella-yellow, alſo aſh-grey, yellowiſh and greyiſh white. It is dull, and is compoſed of more or leſs cohering duſty particles; it ſoils a little, is meagre, and ſomewhat rough to the touch. It is light, ſometimes almoſt ſufficiently ſo as to float on water.

It efferveſces powerfully with acids, and is readily fuſible by the blowpipe.

It occurs in beds in ſecondary limeſtone and the more recent ſandſtone, and frequently contains ſhells. It is employed in pottery, but its moſt important uſe is in agriculture as a manure for four clay, ſand, or peat.

2. *Subſp.* Indurated marl. *Verhärteter mergel*, Wern. *Marne endurcie*, Broch.

Its colour is ſmoke-grey, yellowiſh, bluiſh, or blackiſh grey, yellowiſh-white, ochre-yellow, and browniſh-red. It occurs in maſs. It is dull, ſometimes ſlightly glimmering from an admixture of foreign particles. Its fracture is earthy, or ſplintery paſſing into conchoidal, or ſlaty. It breaks into indeterminately angular or ſlaty fragments. It is opake, moderately ſoft, brittle, and eaſily frangible.

Like the preceding it forms a greyiſh-black glaſs before the blowpipe, and efferveſces vigorouſly with acids.

It occurs principally in ſecondary limeſtone, alternating in beds with it or forming neſts in it: it is alſo met with in the independent coal formation.

It readily diſintegrates by expoſure to the weather, and is in great requeſt with the farmer. It frequently contains ſhells.

In agriculture the following varieties of marl are uſually diſtinguiſhed.

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[b] Memoires.

Common marl, which includes not only the earthy marl but ſome varieties of potters clay: ſtone marl, which is the earthy indurated; ſlate marl, which is the ſlaty indurated; and ſhell marl, which is either the earthy or indurated, abounding with ſhells.

MARLITE, *bituminous*, Kirw. *Bituminöſer mergelſchiefer*, Wern. *Schiſte marno-bitumineux*, Broch.

Its colour is greyiſh or browniſh black. It occurs in maſs. The ſurface of its fracture is either rough and dull or ſlightly glimmering, or ſmooth and gliſtening or ſhining.

Its fracture is plane or waved ſlaty. Its fragments are ſlaty. It is opake, acquires a poliſh by friction, is ſoft, eaſily frangible, ſomewhat meagre to the touch, and moderately heavy.

It efferveſces with acids, and when expoſed to the blowpipe gives out a bituminous odour and a weak flame, and then fuſes into a black ſcoria.

It occurs in beds with the oldeſt ſecondary limeſtone. It is often mixed, more or leſs, with various ores of copper, eſpecially the pyritical and vitreous; alſo more rarely with the blue or green carbonated or native copper. When this is the caſe it is often regularly worked as an ore of copper.

A remarkable circumſtance relating to this mineral is, that it contains petrified fiſh and vegetable remains, arranged in regular bands; the bodies of the fiſh are carbonized, and their ſcales often plated with copper ore: notwithſtanding the regularity of the layers each fiſh is in a contorted and convulſed poſition, as if it had ſuddenly undergone a violent death.

It occurs at Eiſleben and Ilmenau in Thuringia, and Riegelſdorf in Heſſia.

MARTIAL ETHIOPS. See IRON, p. 612.

MARTIAL FLOWERS. See IRON, p. 622.

MARTIAL REGULUS OF ANTIMONY. See ANTIMONY, p. 80.

MARTIAL TINCTURE. See IRON, p. 622.

MARTIAL VITRIOL. See IRON, p. 614.

MASSICOT. See LEAD.

MASTICH.[a]

The piſtachia lentiſcus is a ſmall tree, about ten or twelve feet high, that grows in ſeveral of the iſlands of the Archipelago, but is cultivated with peculiar care and ſucceſs in the iſland of Chio. In the month of Auguſt tranſverſe inciſions are made in the bark of this tree, from which there oozes out in the ſpace of a few hours a pellucid reſin. This reſin is called maſtich, and when pure is in the form of little round drops or tears, of a very pale amber colour; a piece recently broken is quite tranſparent, but by expoſure to the air it becomes ſomewhat pulverulent ſuperficially, and hence ſemitranſparent. Its ſp. gr. is 1.074. This reſin, eſpecially when gently warmed, has a faint but not unpleaſant odour, which becomes ſtronger and more grateful when it is melted; it has ſcarcely any ſenſible flavour; when maſticated it grows ſoft like wax, and acquires an ivory whiteneſs; water boiled upon it becomes impregnated with its odour, but the maſtich loſes hardly any weight by the proceſs.

In its habitudes with acids and alkalies maſtich does not perceptibly differ from the other reſins. By digeſtion with alcohol it is ſeparated into two portions; the one ſoluble in this fluid and the other inſoluble; the former compoſes about $\frac{4}{5}$ of the whole, and is pure reſin; the latter in moſt of its properties cloſely reſembles caoutchouc. The preſence of this ſubſtance in maſtich was firſt remarked by Kunde, an apothecary of Berlin, whoſe obſervations have ſince been confirmed by Mr. Matthews.[b] After ſolution of the reſin in alcohol an inflammable reſidue is left behind of a white colour, conſiderably elaſtic and adheſive; when heated it becomes brown, emitting an inflammable gas, and in this ſtate greatly reſembles common caoutchouc, except in being ſlightly glutinous. It is perfectly ſoluble in waſhed ſulphuric ether from which it is precipitable by alcohol in the form of a white curd. It is wholly inſoluble in water. By digeſtion with nitric acid it is converted into a yellow brittle porous maſs, nitrous gas being at the ſame time given out; it is charred by ſulphuric acid, to which it communicates a deep (ſomewhat muddy) crimſon colour, with the evolution of ſulphureous acid. Neither the muriatic nor oxymuriatic acids, nor the alkalies whether cauſtic or carbonated, have any action on it: in all which particulars it agrees with caoutchouc.

In the Turkiſh dominions maſtich is in great requeſt among the women, as a maſticatory, and the produce of the Chian plantations is ſaid to be appropriated to the uſe of the emperour's ſeraglio. In the other countries of Europe it is employed medically in fumigations, and by painters and other artiſts in the compoſition of the tougher kinds of varniſhes.

MATRASS, an article of chemical apparatus. See APPENDIX.

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[a] Murray, Apparat. Med. I. p. 127.

[b] Nich. Journ. x. p. 247.

MATT. The produce of the firſt fuſion of a ſulphuretted ore is called a *matt*, a term probably adopted from the German miners; for the word in that language ſignifies dull, without luſtre, a character that is applicable with great juſtice to moſt of the half ſulphurized reguli when compared to the ſame metals in their pure ſtate.

MEASURES and WEIGHTS. See the Appendix.

MEERSCHAUM[a] Wern. Ecume de mer, French. Keffekil, *Kirw.*

Its colour is yellowiſh-white paſſing to Iſabella-yellow, or greyiſh or reddiſh. It occurs in maſs. It is dull. Its fracture is fine-grained, earthy, paſſing into flat conchoidal, or ſmall ſlaty; its fragments are indeterminately angular, moderately ſharp-edged. It is opake, ſoft, eaſily frangible, acquires a poliſh by friction, is more or leſs unctuous to the touch, ſp. gr. 1.6.

It is partly ſoluble in acids without efferveſcence, and is infuſible, without addition, before the blowpipe.

It has been analyſed both by Wiegleb and Klaproth with the following reſults:

	Wiegleb	Klaproth	
Silex	54.16	50. 5	41
Magneſia	51.66	17.25	18.25
Lime	——	0.5	0.5
Water	——	25.	39.0
Carbonic acid	——	5.	
	105.82	98.25	98.75

Much of the apparent difference between theſe analyſes will be removed by obſerving that Klaproth analyſed the freſh earth, whereas the ſpecimen examined by Wiegleb was a tobacco pipe made of the ſame earth, but of courſe baked, and therefore deprived of water and carbonic acid. A third ſpecimen analyſed by Klaproth yielded conſiderably more magneſia and leſs ſilex than the other two, and therefore approached nearly to that examined by Wiegleb.

Meerſchaum is uſed in various parts of the Turkiſh dominions as fullers' earth is with us; it is alſo employed by the Turkiſh women inſtead of ſoap in waſhing their hair, the bowls of the Turkiſh pipes are alſo made of it.

The moſt valued ſort of this mineral is found in the Crimea, whence it uſed to be exported in great quantity to Conſtantinople under the name of keffekil, or earth of Kaffa, ſo called from the town in the Crimea where it was ſhipped. It is alſo found in Natolia, and the Iſlands of Samos and Negropont in the Archipelago. It forms thin beds, and when recently dug, is ſaid to be in a ſoft paſty ſtate, but becomes harder by expoſure to the air.

An earthy ſubſtance, ſimilar to the above, has been found by Fabbroni at Caſtel del Piano, near Sienna: it conſiſts of 55 ſilex, 25 magneſia, 12 alumine, 3 lime, and 0.1 oxyd of iron; and is the material of which he has made bricks ſo light as to float in the water; thus reſtoring one of the loſt arts recorded by Strabo and Pliny.

MELANITE[a]. Melanit, *Wern.* Black garnet of moſt mineralogiſts.

Its colour is velvet-black inclining to greyiſh-black. It occurs cryſtallized in ſix-ſided priſms, terminated at each extremity by an obtuſe trihedral pyramid, the planes of which are ſet on the alternate edges of the priſm; the priſm itſelf is not unfrequently truncated on its lateral edges. Its cryſtals are middle-ſized and ſmall. Externally it is ſmooth and ſhining, approaching to reſplendent; internally it is ſhining, approaching to glimmering. Its fracture is imperfectly flat conchoidal, with ſometimes a tendency to foliated: its natural joints obliquely interſect each other in two directions. Its fragments are indeterminately angular and ſharp-edged. It is opake, hard, pretty eaſily frangible, ſp. gr. 3.69 to 3.8.

Both Klaproth and Vauquelin have publiſhed analyſes of this mineral, but they differ ſo conſiderably as to render it probable that the one or the other has operated on a different ſubſtance from the true melanite. The following are the reſults.

	Klapr.	Vauq.
Silex	40	35
Alumine	28.5	6
Lime	3.5	32
Magneſia	10.	0
Oxyd of iron	16.5	25
Ditto of manganeſe	0 25	
	98.75	98

It has hitherto been found only in Italy, at Fraſcati, and St. Albano, near Rome.

MELLITE or HONEYSTONE.[a] *Honigſtein*, Wern. *Mellilite*, Kirw. *Mellite*, Broch. *and* Hauy.

Its colour is honey-yellow, paſſing into pale wax and ſtraw yellow. It occurs in detached grains, and cryſtallized. Its primitive figure is an octohedron, formed by two four-ſided pyramids, the common baſe of which is a perfect ſquare, and the incidence of each face in one pyramid, on its correſponding face in the other pyramid is = 93°. 22′. Beſides the above form it preſents the two following varieties.

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[a] Brochant. Jameſon.

[a] Jameſon. Brochant.

[a] Brochant. Hauy. Jameſon.

1. The primitive octohedron with all the ſolid angles replaced by ſmall quadrilateral planes, the ſurfaces of which are not unfrequently curvilinear.

2. The primitive octohedron with the lateral angles deeply truncated, thus forming a dodecahedron, differing however in the meaſurement of its angles from the rhomboidal or garnet dodecahedron.

The cryſtals are ſmall, and very ſmall; their ſurface is commonly ſmooth and ſhining. Internally it is ſplendent with a luſtre between vitreous and reſinous. Its fracture is perfectly conchoidal; its fragments are indeterminately angular. It is tranſparent, paſſing into opake, and poſſeſſes a double refraction. It is ſofter than amber; is brittle, and eaſily frangible. Sp. gr. 1.58 to 1.66. It becomes electric by friction, but continues ſo only for an inſtant.

When ignited in the open air it firſt becomes opake, and of a greyiſh-white ſpotted with black, at length it acquires the colour and conſiſtence of chalk; no ſmoak or flame are obſervable during the whole of this proceſs.

According to the experiments of Klaproth[b] it exhibits the following properties.

When finely pulverized, and boiled with a large quantity of water, it forms an acidulous ſolution, and leaves behind a light-grey ſlimy earth.

It is entirely ſoluble in nitric acid without heat. With muriatic acid it affords a ſomewhat turbid ſolution. In concentrated ſulphuric acid it breaks down into a white flocculent matter, which, by ſubſequent dilution with water, is entirely taken up.

A ſolution of cauſtic ſoda firſt converts mellite into a looſe flocculent ſubſtance, and then diſſolves the greater part of it.

Ammonia, by cold digeſtion for ſome hours in a cloſed bottle, produces a compleat diſintegration: the earthy part is left behind in the form of a greyiſh ſlime, and the acid combines with the ammonia into a cryſtallizable fluid.

Mellite, projected on melted nitre, cauſes a ſlight ſcintillation, and the white earthy part remains mixed with the ſaline reſidue.

When boiled with a ſolution of carbonated ſoda, a moderate efferveſcence takes place, and when this ceaſes, there remains a white earth, which is alumine, with a ſmall caſual admixture of ſilex. The ſupernatant liquor, when exactly neutralized with acetic acid, and evaporated to dryneſs, leaves behind a ſaline maſs, which, after the acetat of ſoda has been waſhed out by alcohol, furniſhes by ſolution in water and evaporation cryſtals of a neutral ſalt. Hence mellite conſiſts eſſentially of an acid and alumine.

The moſt ſatisfactory of the analyſes performed on this ſubſtance by Klaproth, is the following.

a. 400 grains of mellite reduced to a fine powder were boiled three ſeveral times with 60 ounces of diſtilled water each time: there remained behind an earthy reſidue weighing, after being dried, 210 grains.

b. The watery ſolution being concentrated in a gentle warmth, till it became thick, was mixed with alcohol, by which it acquired a pitchy conſiſtence, but at length by continued trituration, it diſſolved in this fluid, with the exception of ſome earthy flocculi, which, when waſhed and dried, weighed 22 grs. When theſe were ſeparated, the clear liquor yielded, by evaporation, a browniſh ſaline maſs, weighing 92 grains.

c. This brown ſalt, by two ſucceſſive evaporations and ſolutions, was procured in diſtinctly cryſtallized needles, and was pure *mellitic acid.*

d. The inſoluble reſidues of *a* and *b*, by expoſure to a red heat, gave out a weak ſweetiſh odour, owing to the combuſtion of a ſmall portion of acid, and were reduced to a greyiſh white powder, weighing 64 grs. This, when treated with four times its weight of ſtrong ſulphuric acid, coagulated into a cryſtalline maſs, which, by re-ſolution in water, left behind 11 grs. of reſidue.

e. Theſe 11 grs. by digeſtion with muriatic acid were reduced to 5.5 which were *ſilex.*

f. The muriatic ſolution of *e* afforded, with pruſſiat of potaſh, a ſmall portion of blue precipitate, indicating 0.5 gr. of *iron.*

g. From the clear ſolution of *f*, carbonated ſoda threw down ſome alumine, which being rediſſolved in ſulphuric acid, was added to the ſulphuric ſolution of *d*. By the addition of acetat of potaſh, the whole ſhot into cryſtals of alum, which, when treated with carbonat of ammonia, afforded *alumine* to the amount of 58 grs. after ignition.

Hence theſe 400 grs. of mellite are compoſed of

5.5	Silex
0.5	Iron
58.0	Alumine
336.0	Mellitic acid, water, and loſs

which gives *per cent.*

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[b] Analyt. Eſſ. II. p. 93.

1.375	Silex
0.125	Iron
14.5	Alumine
84.	Mellitic acid, water, and loſs
100.000	

Mellite is a mineral of very rare occurrence, having hitherto been found only at Aertern in Thuringia, Langenbogen in the diſtrict of Saal, and in Switzerland. It occurs on bituminous wood, and earthy coal, and is generally accompanied by ſulphur.

MELLITIC ACID.[a]

This acid obtained as mentioned in the preceding article, cryſtallizes in finely fibrous and ſpherical maſſes, or in minute ſhort priſms. Its taſte is ſweetiſh-ſour with a bitteriſh flavour. It is decompoſed by ignition into a dark-grey ſmoak, poſſeſſing very little odour, and leaves behind a ſmall portion of aſhes that are neither alkaline nor acidulous. It is not convertible into oxalic acid by digeſtion with nitric acid. If dropped into a ſolution of cauſtic lime, barytes, or ſtrontian, it immediately produces a white precipitate, which, however, is again taken up by muriatic acid. It decompoſes acetat of barytes, acetat of lead, nitrat of mercury, and nitrat of iron, but all theſe precipitates are reſoluble in nitric acid. It produces no change in nitrat of ſilver or muriat of copper. When added to muriat of barytes, it cauſes no alteration at firſt, but ſoon brings on a copious depoſit of cryſtalline needles.

With potaſh it forms a neutral ſalt, of a ſtriated cryſtalline appearance.

With ſoda it affords cryſtals in the form of cubes or triangular plates.

With ammonia it affords clear hexahedral priſms, which, by expoſure to the air, loſe their tranſparency, and acquire a ſilvery-white appearance.

MENACHANITE. See TITANIUM.

MENSTRUUM.

This term is nearly ſynonimous with SOLVENT, which ſee.

MERCURY or QUICKSILVER. *Mercure, Argent vif*, Fr. *Queckſilber*, Germ.

Mercury is a metal of a ſilvery-white colour, and fluid at the uſual atmoſpherical temperature.

§. 1. *Ores of Mercury.*[a]

Sp. 1. Native Mercury. *Mercure natif*, Broch. *Gediegen Queckſilber*, Wern.

Its colour is between tin and ſilver-white. It occurs diſſeminated in globules of various ſizes, or collected in the cavities of mines. It has a very brilliant metallic luſtre, is opake, perfectly fluid, cold to the touch, and does not adhere to the fingers. Sp. gr. 13.56.

Native mercury is generally very pure, but ſometimes it contains a little ſilver, thus forming an intermediate variety between this ſpecies and the next. In proportion to the amount of the ſilver its fluidity is diminiſhed.

It occurs in marlite, calcareous ſpar, indurated clay, argillaceous ſchiſtus, quartz, &c. accompanied for the moſt part by cinnabar and pyrites.

It is met with in the mines of Idria in Carniola, at Moſchellandſberg in Deux Ponts, Almaden in Spain, and Guanca Velica in Peru.

Sp. 2. Native Amalgam. *Amalgame natif*, Broch. *Naturliches Amalgam*, Werm. *Mercure Argental*, Hauy.

Its colour is ſilver-white or greyiſh, ſometimes irideſcently tarniſhed. It occurs rarely in maſs, more commonly diſſeminated, inveſting, in ſmall veins or cryſtallized. The forms of its cryſtals are,

1. The regular octohedron truncated on the edges.
2. The rhomboidal dodecahedron.
3. The preceding truncated on the edges.

The cryſtals are ſmall and very ſmall, and for the moſt part ill determined. Its ſurface varies from much to little ſhining, according as it is ſmooth or rough. Internally it is ſhining or little ſhining, with a metallic luſtre. Its fracture is uneven, paſſing into flat conchoidal. It is ſoft, often very ſoft. It is more or leſs brittle according to the proportion of ſilver that it contains. It creaks when cut; and is very heavy.

On expoſure to the blowpipe the mercury is volatilized, and a bead of pure ſilver remains behind. A cryſtallized ſpecimen, analyſed by Klaproth, afforded

Silver	36
Mercury	64
	100

In ſome of the paſty ſemifluid varieties however, the proportion of ſilver is as low as 10 per cent.

It has ſometimes been miſtaken for native ſilver, but may be at once diſtinguiſhed by its property of whitening gold when rubbed upon it.

It occurs only in thoſe mines where veins of mercury are croſſed by or mixed with others of ſilver. Hence it never occurs in the mines of Idria or Almaden, but is far from rare in thoſe of Roſenau, in Upper Hungary; it is alſo met with at Sahlberg in Sweden, Mörsfeld, in the Palatinate, and Moſchellandſberg, in Deux Ponts.

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[a] Klaproth.

[a] Lenz. Born. Emmerling. Brochant. Kirwan. Hauy. Jameſon.

It is uſually found in red and grey indurated clay, accompanied by native mercury, ſpathoſe iron ore, grey antimony, and grey copper.

Sp. 3. Liver-coloured mercurial ore. *Queckſilber lebererz*, Wern. *Mercure hepatique*, Broch. Of this ſpecies there are the two following varieties.

1 *Var.* Compact.

The colour is intermediate between dark cochineal red and lead-grey. It occurs maſſive. Internally it has a gliſtening ſemi-metallic luſtre. Its fracture is even, paſſing into fine grained uneven, or imperfectly flat conchoidal. Its fragments are indeterminately angular, ſomewhat blunt edged. It is opake; receives a poliſh by friction, and gives a ſtreak of a cochineal red colour. It is ſoft, may be cut by a knife, and is eaſily frangible, ſp. gr. 7.18 to 7.93.

2 *Var.* Slaty.

Its colour is the ſame as the preceding, only a little more red. It occurs in maſs. Its longitudinal fracture is ſhining with a metallic luſtre; its croſs fracture is only glimmering. Its longitudinal fracture is thick and curved ſlaty; its croſs fracture is compact and even. Its fragments are ſlaty; it is opake, and very eaſily frangible.

Both theſe varieties are mixed with cinnabar, native mercury, iron pyrites and clay. The produce of mercury varies from leſs than 20 to more than 70 per cent; the compact is uſually the richeſt, containing a leſs proportion of earthy matter than the other. It has not been analyſed with much accuracy, but it appears that at leaſt a conſiderable portion of its mercury is in the ſtate of ſimple red oxyd.

It occurs in abundance at Frioul in Iſtria, Almaden in Spain, in the Duchy of Deux Ponts, and Nertſchinſk in Siberia.

Sp. 4. Bituminous mercurial ore.

Of this there are the two following varieties.

1. *Var.* Branderz.

This is a kind of coarſe coal of a reddiſh-black colour. It occurs in maſs, or in balls diſſeminated through bituminous ſhale. When heated it takes fire, and burns with a white flame.

2. *Var.* Corallenerz.

This is the bituminous ſhale in which the balls of the preceding variety are implanted, and, like that, it burns when heated, with a white flame.

The bituminous mercurial ore occurs at Idria in Carniola, and Nertſchinſk in Siberia, in conſiderable abundance: it contains from 2 to 20 per cent. of mercury. It has not been analyſed, but it is certain that part of the mercury that it contains is in the native ſtate, the reſt is ſuppoſed for the moſt part to be in the ſtate of muriat.

Sp. 5. Cinnabar. *Zinnober*, Wern. *Cinnabre*, Broch.

Of this there are the three following ſubſpecies.

1. *Subſp.* Common, or dark red, C. *Dunkel rother*, Z. Wern.

Its colour is cochineal-red, which in ſome varieties paſſes to carmine-red, and in others to lead-grey. It occurs in maſs, diſſeminated, inveſting, cellular, dendritic or cryſtallized. The primitive form of its cryſtals is the regular hexahedral priſm, beſides which the following varieties occur.

1. The ſame with three alternate terminal edges of the priſm deeply bevilled.
2. A tetrahedral pyramid.
3. An octohedron, compoſed of two tetrahedral pyramids.
4. A ſingle trihedral pyramid.
5. A double trihedral pyramid, either with or without an intervening trihedral priſm.
6. The ſame as *var.* 1. curved into a lenticular form by the addition of ſeveral irregular truncatures.

The cryſtals are ſmall, and very ſmall, and uſually occur in cluſters. The cryſtals are ſplendent externally and internally, are more or leſs ſhining with almoſt a ſemi-metallic luſtre. Its fracture is fine-grained uneven, ſometimes even and conchoidal; alſo as it approaches to the cryſtalline ſtate, more or leſs perfectly foliated. Its fragments are indeterminate and blunt-edged. The foliated varieties preſent fine-grained diſtinct concretions. The maſſive cinnabar is opake, or at moſt tranſlucent on the edges; the cryſtallized is tranſlucent, and ſemitranſparent. It acquires a luſtre by friction, and when pulverized is of a ſcarlet-red colour. It is ſoft, may be cut with a knife, and is eaſily frangible. Sp gr. of the compact, when moderately pure, 7.2 to 7.3; of the cryſtallized, 10.12. Its conſtituent parts according to Lampadius are

81.	Mercury
15.2	Sulphur
4.7	Iron
100.9	

Before the blowpipe it is almoſt entirely volatilizable with a blue flame, and a ſulphureous odour.

Cinnabar occurs in two diſtinct rock-formations. It is found moſt abundantly in the independent coal-formation: alſo in beds interpoſed between primitive argillaceous ſchiſtus and chlorite ſlate, accompanied by quartz, calcareous ſpar, ſpathoſe iron, micaceous iron, and iron and copper pyrites.

The moſt abundant European mines of Cinnabar are at Idria in Carniola, and Almaden in Spain, in the independent coal-formation. It occurs more ſparingly in primitive ſtrata at Mörsfeld in the Palatinate, Moſchellandſberg in the territory of Deux Ponts; alſo in Saxony, Bohemia, Hungary, and Tranſylvania. It is met with in Japan, Kamtſchatka, and Siberia in Aſia, and near Guanca Velica in Peru.

2. *Subſp.* Fibrous cinnabar. *Hochrother*, Z. Wern.

Its colour is bright ſcarlet, paſſing to crimſon and Aurora-red. It occurs in maſs and diſſeminated. Internally it is glimmering with a ſilky luſtre, but its croſs fracture is dull. Its fracture in one direction is fine-grained earthy, in the other is minutely fibrous. Its fragments are indeterminately angular, blunt-edged; it is opake; acquires a ſlight poliſh by friction, and when pulverized is of a ſcarlet-red. It ſtains the fingers in a ſmall degree; is very ſoft, paſſing to friable; may be cut with a knife; and is of great ſpecific gravity.

It is a rare mineral, and is always accompanied by the preceding ſubſpecies: it is principally found in the Palatinate.

3. *Subſp.* Hepatic Cinnabar. *Cinnabre alcalin*, Born.

Its colour is bright-red; it occurs in maſs; its fracture is foliated; its fragments are rhomboidal; it is tranſparent. By friction it exhales a very ſtrong odour of ſulphuretted hydrogen. It occurs in white calcareous ſpar at Idria in Carniola.

Sp. 6. Horn Mercury. *Queckſilber Hornerz*, Wern. *Mine de mercure cornée*, Broch.

Its colour is aſh-grey, paſſing into yellowiſh-grey, greyiſh-white, and greeniſh-grey; when penetrated as it ſometimes is with native mercury it is blackiſh-grey. It occurs very rarely in maſs, moſt frequently in ſmall and thin tubercular cruſts, the cavities of which are lined with minute cryſtals, alſo in ſmall globules formed by the aggregation of cryſtals. The only well aſcertained form of its cryſtals is a dodecahedron compoſed of a four-ſided priſm terminated by tetrahedral pyramids: the planes of the priſm are hexagons, thoſe of the ſummits are rhombs. The cryſtals are generally very ſmall and ſplendent. Internally they are ſplendent with a diamond luſtre, paſſing ſometimes to metallic. The fracture as far as it can be obſerved is ſtrait lamellar. It ſometimes preſents fine-grained diſtinct concretions. It is faintly tranſlucent; ſoft; may be cut with a knife, and is eaſily frangible.

On expoſure to the blowpipe it is totally volatilized without decompoſition. It is ſoluble in water, and the ſolution gives an orange-coloured precipitate with lime-water. The only analyſis of this mineral that we poſſeſs is an imperfect one by M. Woulfe, the diſcoverer of it, from which it may be concluded, with conſiderable probability, that it conſiſts when pure of about

64	Sulphat of mercury
36	Muriat of mercury
100	

It occurs in the quickſilver mines of the Palatinate, and Deux Ponts; at Idria, Horſowitz in Bohemia, and Spain.

§. 2. *Analyſis and Aſſay.*

There are no very exact analyſes of any of the mercurial ores, but the following methods of examining them ſeem to be liable to little or no objection.

The *native mercury* and *native amalgam* may be thus analyſed. Let the ore be digeſted in moderately ſtrong nitric acid, which will take up the mercury, and ſilver, and biſmuth, if there ſhould chance to be any preſent: a minute quantity of gold may alſo be contained in the argentiferous mercury, which will be left untouched at the bottom of the ſolution, in the form of a brown powder. The nitrous ſolution being concentrated by gentle evaporation, till it is on the point of cryſtallizing, is to be poured into a large quantity of pure water, by which the biſmuth will for the moſt part be ſeparated. Having thus got rid of the biſmuth, add to the filtered liquor a ſolution of common ſalt or any other neutral muriat, by which both the ſilver and mercury will be thrown down in the ſtate of muriat. This being ſeparated, drop into the clear liquor ſome carbonated alkali as long as any precipitate takes place, then boil the liquor, and ſeparate the precipitate by filtration. The muriatic precipitate is now to be digeſted in moderately dilute nitro-muriatic acid, which will take up every thing but the muriat of ſilver, from which, when waſhed and dried, the amount of ſilver in the ore may be readily aſcertained. Now decompoſe the nitro-muriatic ſolution at a boiling heat by carbonated alkali, and add the white precipitate thus obtained to the other carbonated precipitate; mix theſe with a little oil or ſugar (the latter is the beſt) and proceed to diſtillation in a ſmall coated glaſs retort; raiſe it gradually to ignition, and continue it at that temperature as long as any mercury comes over. What remains behind is a little metallic biſmuth and charcoal.

Cinnabar may be analyſed in the following manner. After being reduced to a fine powder, let it be digeſted repeatedly in a mixture of 3 parts muriatic acid and 1 nitric, the whole moderately diluted; by this every thing will be taken up except the ſulphur and the ſilex. This reſidue being waſhed, dried, and weighed, is to be ignited, and the remaining ſilex being deducted, the difference of weight indicates the amount of the ſulphur. The nitro-muriatic ſolution being decompoſed by carbonated alkali at a boiling heat, and the precipitate thus obtained being mixed with a little lamp-black and diſtilled, the mercury will paſs over in the metallic ſtate: what remains in the retort is magnetic oxyd of iron, and the caſual earth (excepting ſilex) contained in the ore, together with a little charcoal, which may be ſeparated in the uſual way.

The *liver-coloured* and *bituminous ores* may be treated exactly in the ſame manner as the preceding; but as theſe ores ſometimes contain a little ſilver, the matter inſoluble in nitro-muriatic acid may be not merely ſulphur and ſilex but muriat of ſilver; after therefore the ſulphur is burnt off, the reſidue mixed with twice its weight of pearlaſh is to be ſtrongly ignited in an earthen crucible, and then treated with dilute muriatic acid which will take up the alkali and earth leaving behind the ſilver in ſmall metallic grains.

The beſt way of analyſing the horn mercury is to digeſt it in a little diſtilled vinegar, by which the native mercury which is ſometimes diſperſed through it will be left behind. To the clear ſolution add nitrat of barytes, which will ſeparate the ſulphuric acid in the ſtate of ſulphat of barytes: this being taken out, drop in nitrat of ſilver, which will ſeparate the muriatic acid in the ſtate of muriated ſilver. The mercury, now in the ſtate of nitrat, remains in ſolution, and may be exhibited in the metallic ſtate by precipitating it by means of iron and ſubſequent waſhing in muriatic acid; or by throwing it down by a carbonated alkali, and diſtilling the precipitate with a little lamp-black.

The aſſay of mercurial ores in the dry way is very ſimple. The ſpecimen being pulverized, and accurately mixed with $\frac{1}{4}$ of its weight of quicklime and an equal portion of iron filings, is to be pretty ſtrongly ignited in an iron or earthen retort as long as any mercury comes over into the receiver.

§. 3. *Reduction of ores.*

The modes of extracting the metal from the ores of mercury are very ſimple. The firſt that we ſhall mention is the beſt and moſt ſcientific, and practiſed at the mines of Deux Ponts, and of Idria. The ore being brought out of the mine, is ſorted by hand with conſiderable accuracy, rejecting thoſe parts that appear to be deſtitute of metal. This is an expenſive and rather tedious proceſs, but has ſuperſeded the ancient method of ſeparating the cinnabar by waſhing, on account of the prodigious loſs of metal in that operation. The ſorted ore being reduced to powder is carefully mingled with $\frac{1}{5}$ more or leſs, according to the proportion of cinnabar contained in the ore, of quicklime which has fallen to powder by expoſure to the air. This mixture is then put into iron retorts, capable of holding about 60 lbs. weight, which when thus charged, are fixed in a long furnace, to the number of 40 or 50: a glaſs receiver being then attached to each retort, but not luted, a gentle fire is applied in order to drive out all the moiſture; when this is effected, the juncture of the veſſels is cloſely ſtopped with tempered clay, and a full red heat is applied for ſeven or eight hours, at the expiration of which time all the mercury will have been volatilized and condenſed in the receiver. The common produce varies between ſix and ten ounces of metal from 100 lbs. of the ore.

The method practiſed at Almaden, in Spain, differs conſiderably from the preceding, and is much more rude and inartificial. The pieces of pure cinnabar being firſt picked out from the ore, in order to be diſpoſed of to the painters, and manufacturers of ſealing wax, the reſt is ſorted into three parts, the firſt is the richeſt, and is in pieces of a moderate ſize, the ſecond is in ſmaller pieces, and leſs abounding in metal, the third is the duſt and ſmalleſt fragments of the other two, which are kneaded up with clay, and formed into bricks, that are dried carefully in the ſun. The furnace uſed for extraction of the mercury is an oblong maſs of maſonry, divided horizontally into an upper and lower compartment by an iron grate, and communicating near its top with a ſet of aludels. The charging of the furnace commences by laying on the grate a ſtratum of flat rough ſtones, leaving intervals between each for the paſſage of the fire: upon this is laid a bed of ore of the ſecond quality, then the ore of the firſt quality, afterwards another bed of the ſecond kind, and at the top of all a layer of the third kind made up into bricks. A few faggots are now thrown into the lower cavity of the furnace and lighted, which, in proportion as they are conſumed, are ſucceeded by others, and thus a gentle fire is kept up for 8 or 12 hours, according to the previous dryneſs of the ore. When the moiſture is got rid of, which is known by the ceſſation of the vapour, the fire-place is again filled with faggots, and, before theſe are conſumed, the maſs of ore will be ſufficiently heated to continue the combuſtion by means of the ſulphur that it contains without any additional fuel. During the next two days, as the ſulphur ſlowly burns away, the mercury, in the ſtate of vapour, paſſes into the aludels where it is condenſed; and at the end of this period, all the metal being extracted, the ſcoriæ are taken out of the furnace, and the aludels are emptied of their contents. Beſides the mercury, a conſiderable quantity of a black matter like ſoot is found in the aludels, which is readily ſeparated by ſpreading the whole about on an inclined table: the mercury runs to the lower end, where it is collected in a channel, while the impurities remain behind.

The conſumption of fuel and coſt of apparatus is conſiderably leſs than in the German method, but it is probable that a portion of mercury ſtill remains in the ore. A great loſs is alſo ſuſtained by throwing away the ſoot after ſeparating the running mercury on the tables, for not only many globules of the metal muſt eſcape notice, but alſo the calomel, cinnabar, &c. which it contains, are entirely waſted. This ſoot, previous to the ſeparation of the mercury, conſiſts, according to Prouſt[b], of

Mercury . .	66
Calomel . .	18
Cinnabar . .	1
Water & ſulphureous acid	2.5
Sulphat of ammonia	3.5
Lamp black .	5
Selenite . .	1
	97.0
Loſs	3.
	100.0

Hence the obvious way of turning it to moſt profit would be firſt to diſſolve out the ſulphat of ammonia, which might be diſpoſed of to great advantage to the ſal-ammoniac makers, then to mix the reſt with 12 or 15 per cent. of quicklime, and diſtill it in an iron retort, by which proceſs not only the whole of the running mercury would be driven over, but alſo that ariſing from the decompoſition of the calomel and cinnabar.

On account of the fluidity of mercury it cannot be conveyed from place to place without extraordinary precautions. The method of packing it is as follows. A freſh ſound ſheepſkin with the hair taken off is laid over a wooden bowl, and from 50 lbs. to 75 lbs. of mercury are poured into it; the ends of the ſkin are then gathered up, and tied together with great care, thus forming a ſort of bag in which the metal is incloſed; this bag is incloſed in a ſecond ſkin, and the ſecond in a third: laſtly, theſe bags are put into very tight barrels, capable of holding from two to four of them, and in this ſtate are brought into the market.

§. 3. *Phyſical and Chemical properties.*

MERCURY is a metal always fluid at the temperature of our climates, of a white and perfectly reſplendent poliſhed ſurface, ſo as to reflect with extreme brilliance all objects, and is without ſmell or taſte in the metallic ſtate. Its ſpecific gravity is 13.56. Its expanſion by heat is on the whole very regular till a conſiderable diſtance above the point of boiling water, and hence its uſe in the conſtruction of *thermometers*. When expoſed to a cold of about —39 it ſolidifies, and when hard frozen it will bear gentle blows with a hammer, ſufficient to prove its malleability, though in ſo doing the friction ſoon heats it enough to make it reaſſume the liquid ſtate. Mercury boils at about 660°, and, if pure, totally evaporates without any reſiduum: but the vapour ſoon condenſes upon the adjacent bodies, coating them with a white dew, which is found by the microſcope to conſiſt of myriads of minute globules. When the galvanic fluid from a powerful apparatus is paſſed into mercury by immerſing the conducting wire into this fluid the mercury diſperſes in beautiful, brilliant, luminous ſtars, which ſeems to ſhew that this is a combuſtible metal.

Mercury is ſcarcely if at all changed by mere expoſure to air for any length of time, but if it be long agitated in any veſſel it is ſlowly reduced to a black duſt, ſoiling the fingers, which, however, on being heated, returns again to the ſtate of running mercury. Boerhaave was the firſt who performed this experiment by faſtening a bottle half full of mercury to a mill wheel, and thus giving it a very long continued and violent ſhaking. The ſame has been done by faſtening it to the wheel of a carriage during a long journey. Dr. Prieſtley[c] found this black powder to be formed in a variety of circumſtances by a long agitation of mercury in phials with water, alcohol, &c. This powder heated gradually on an iron plate became of an uniform orange colour, and when digeſted in muriatic acid, it gave exactly the ſame appearances as the red oxyd, the precipitate per ſe. This black mercurial powder is ſtated by Fourcroy[d] to be compoſed of 96 parts of mercury and 4 of oxygen, though by others it is conſidered as mercury ſimply in a ſtate of extreme diviſion. Mercury is brought to the ſame ſtate by being rubbed for ſome time with lard, gum arabic, honey, manna, vegetable extract, or any other clammy coheſive matter, which ſoon becomes black, or rather of a dark ſlate blue, by the divided metal. In this way mercury is conſtantly prepared for medicinal purpoſes.

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[b] An. de Chim. iv. p. 226.

Another and very important oxyd of mercury is made by keeping it nearly at its boiling point, and at the ſame time with ſufficient acceſs of air. This is generally performed in a very flat bottomed matraſs with a tall neck, the mouth of which is unſtopped, and which is ſet on a ſand-heat, and kept there for many days. In this proceſs as a certain renewal of the atmoſpheric air is required on the one hand, and on the other as the eſcape of the vapour of the boiling mercury ſhould be prevented, it is rather difficult to contrive the beſt form of veſſel for preparing it. If the neck be very narrow there is ſcarcely enough change of the air in contact with the mercury, ſo that on the whole it ſeems preferable to uſe a retort with the bottom flattened, and the neck only ſlightly bent, that the condenſed globules of mercurial vapour may fall back into the veſſel.[e] When the mercury has boiled for a few hours, a dull film forms on its ſurface, giving it the appearance of tarniſhed lead, and in about 48 hours after, ſmall cryſtals of a dark brown or flea-coloured oxyd appear floating on the ſurface, which gradually increaſe till they form a friable cruſt over the whole of the metal. It is economical at this time to empty the retort, and ſeparate the oxyd, which, when carefully collected, ſhould be heated on an open pan in a heat juſt below viſible redneſs, to diſſipate the globules of uncalcined mercury which may be entangled within the cryſtals.

This brown oxyd is called *Calcined Mercury* or *Precipitate per ſe*, and is a perfectly pure oxyd of this metal of a dull ruby colour, and often regularly cryſtallized either in octohedrons or in lengthened four-ſided pyramids. It conſiſts, according to Lavoiſier[f], of about 92 per cent. of mercury and 8 of oxygen. If this oxyd is kept ſome time gently heated with contact of air it becomes brown, and with a ſtronger heat (ſtill below redneſs) it partly ſublimes of a fine red. But when the heat is raiſed to redneſs the oxyd gradually diſappears, oxygen gas of great purity is given out, and the metal returns to the reguline ſtate, and may be collected in drops of running mercury. This experiment which from its ſimplicity is one of the moſt unexceptionable in ſupport of the preſent theory of the oxydation of metals, was employed very early by Lavoiſier, as will be mentioned under the article Oxygen.

When this oxyd is rubbed with running mercury[g] both ſubſtances loſe their peculiar form, and the reſult is a black powder reſembling in every reſpect the black oxyd procured from this metal by trituration, the red oxyd parting with a portion of its oxygen to the freſh mercury, and each being thereby converted to the black oxyd.

Another oxyd of this metal, very cloſely reſembling the *precipitate per ſe*, is prepared by diſtilling nitric acid off this metal, which forms that beautiful red powder called *Red Precipitate*, or Red *Nitrous oxyd of mercury*. It is however not abſolutely pure like the laſt, but always contains a very minute portion of nitric and of muriatic acid, and hence when reduced by diſtillation in a red heat, ſome azotic gas is given out, together with a little vapour of corroſive ſublimate, owing to the muriatic acid from which the nitric acid is never abſolutely free.

The oxygen gas from each oxyd alſo holds in ſolution a ſmall portion of mercury in the ſtate of vapour, which is gradually depoſited, but is ſufficient, when recent, to cauſe a ſalivation in the perſons that frequently inhale it. The exact preparation of the red precipitate will be preſently noticed.

Water either hot or cold has no aſcertainable effect upon mercury, but if common mercury, which generally contains a little alloy of other metals, be boiled with water, the latter becomes turbid, acquires a metallic taſte, and with it the power of deſtroying inſects.

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[c] On Air, vol.iii. p. 468.

[d] Jour. des Mines, No. 70.

[e] Higgin's Minutes.

[f] Elements of Chemiſtry.

[g] Fourcroy Syſteme, tom. v.

The ſalts produced by the union of mercury with the different acids have been more examined than thoſe of perhaps any other metal, and require to be deſcribed ſomewhat at large. The Sulphuric acid has no action on mercury in the cold, but when heated, ſolution immediately begins, attended with a copious production of ſulphureous acid vapour, which vapour received in water produces the liquid ſulphureous acid in great purity, which is often prepared in this way. The mercury of courſe becomes oxygenated by the deoxygenation of the acid, and the oxyd diſſolves in the remaining acid forming a ſulphat of mercury. There are however as has been ſhewn by ſeveral chemiſts, and particularly by the accurate experiments of Fourcroy, ſeveral diſtinct ſalts and combinations of ſulphuric acid and oxyd of mercury produced either by the proportions of the ingredients, or by the heat employed. Two parts of mercury to three of ſtrong ſulphuric acid are the proportions generally uſed. If the diſtillation of the acid from off the metal is ſtopped when the mixture has become a white ſaline maſs, but before it is actually dry, the ſalt is very acrid and corroſive, with a ſtrong exceſs of acid, and deliqueſces if expoſed to the air. In this ſtate it is called by Fourcroy the *Acid Sulphat of Mercury*, or as we ſhall here term it the *ſuper-ſulphat of Mercury*. This ſalt may contain a variable proportion of acid, and it is more ſoluble in water as the quantity of acid is greater. On the average it requires about 155 parts of cold water and only 33 of boiling water, and gives an orange precipitate with the fixed alkalies. If this ſalt be waſhed with a much ſmaller quantity of cold water than is neceſſary to diſſolve it, it loſes a part of the mercurial oxyd together with the whole exceſs of acid, and if the waſhing be continued with ſmall doſes of water till the liquor ceaſes to turn blue vegetable colours red, and to give any proof of acidity, the ſalt that is left is found to be much changed in its nature. It is now white and not very acrid, requires for ſolution as much as 500 parts of cold, and about 250 of boiling water, and when cryſtallized from the hot ſaturated ſolution it appears in fine acicular priſms, which when dry, contain according to Fourcroy (the diſcoverer of this ſalt) 75 parts of mercury, 8 of oxygen, 12 of ſulphuric acid, and 5 of water. The pure alkalies and lime-water alſo precipitate the metallic oxyd of a grey colour. In this ſalt the acid and metallic oxyd appear in a ſtate of mutual ſaturation, and hence it ſhould be termed ſimply *ſulphat of mercury*. As it differs from the *ſuper-ſulphat* merely by loſing the exceſs of acid, ſo it may readily be reſtored to that ſtate by adding acid, and then its ſolubility in water proportionally increaſes, and it gives an orange precipitate by alkalies.

There is ſtill another ſulphat to be noticed. If the white ſaline mixture of ſulphuric acid and mercury, or the ſuper-ſulphat above deſcribed, be urged ſtill further in the fire in a heat conſiderably above that of boiling water, it parts with a ſtill greater portion of acid, and becomes a dry hard grey maſs.

If this be taken from the fire and boiling water poured on it, it immediately falls into a lemon-yellow powder, which, when well edulcorated with cold water, forms a well-known mercurial preparation, the *Turbith mineral*, or as Fourcroy names it, the *ſulphat of mercury with exceſs of oxyd*, or in other words, the *ſub-ſulphat of mercury*. In making this preparation it is eſſential that all the exceſs of acid ſhould be driven off by heat before the boiling water is added, otherwiſe the change of colour takes place very ſlowly and partially, and the water diſſolves the remainder.

Turbith mineral approaches very nearly to the ſtate of a ſimple oxyd; however it ſtill retains a portion of acid, and hence, when heated ſtrongly without addition, it gives out water and ſulphureous acid gas, after which comes over a conſiderable quantity of oxygen gas, and laſtly the reduced mercury diſtills over in its metallic form. Turbith alſo differs from both the ſuper ſulphat and ſimple ſulphat of mercury, in being diſſolved and decompoſed by the nitric acid. It is likewiſe nearly inſoluble in water, though, according to Fourcroy, a ſolution is effected by 2000 parts of cold water. When rubbed with running mercury the globules of the latter diſappear, and the whole is changed to a black oxyd. A hundred parts of turbith contain 10 of ſulphuric acid,[h] 76 of mercury, 11 of oxygen, and 3 of water.

The action of ammonia upon the ſulphats, and on moſt of the other ſalts of mercury, is intereſting and ſomewhat complicated. The experiments of Fourcroy have aſſiſted materially in explaining this ſubject. When ammonia is added to a neutral ſalt of mercury (the ſulphat for example) three ſeparate actions take place:

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[h] Fourcroy.

1ſt. one portion of the alkali acts ſimply as an alkali in decompoſing the ſalt by uniting with the acid and precipitating the metallic oxyd:—2dly, the precipitated oxyd is entirely decompoſed by, and together with, another portion of the ammonia, the hydrogen of the ammonia, uniting with the oxygen of the metal, and reducing the latter to the metallic ſtate, whilſt the azot of the alkali eſcapes in the gaſeous form: and 3dly, another portion of the ammonia unites with the entire ſalt without decompoſition, forming a triple ſalt, the *ammoniaco-ſulphat of mercury*. The reduced metal is in a ſtate of extreme diviſion, and is always of a dark blue or black colour, but by a magnifier the diſtinct globules of the metal may be ſeen. The black colour always aſſumed by almoſt all the ſalts of mercury, on adding ammonia, is therefore a proof of a partial reduction of the metal.

Hence when ammonia is poured into a ſolution of the *neutral* ſulphat of mercury, a copious grey precipitate is depoſited, which, expoſed to the ſun, is partly reduced to globules of mercury, whilſt a grey powder remains. This grey powder is a triple ſalt, the ammoniaco-ſulphat of mercury. If a great exceſs of ammonia is added, this ſalt is entirely rediſſolved, and the black reduced mercury is left pure. The ſame triple ſalt is formed by adding ammonia to the ſolid ſulphat of mercury, which then effervеſces ſtrongly (owing to the eſcape of azotic gas) and the ſalt breaks to pieces with a ſnapping noiſe. If the liquor which holds the triple ſalt in ſolution by means of the exceſs of ammonia be evaporated gently, the exceſs is volatilized, and the triple ſalt is depoſited, after ſome hours ſtanding, in brilliant hard polygonal cryſtals. If, inſtead of waiting for this gradual cryſtallization, much cold water be added to the ſolution, it becomes at once milky, and the ſame ſalt is depoſited, only differing from the former in being pulverulent inſtead of cryſtallized. If perfectly neutralized ſulphat of ammonia be poured upon equally neutralized ſulphat of mercury, a copious white precipitate is formed, which is the triple ſalt above-mentioned, and the ſupernatant liquor now contains a ſenſible exceſs of ſulphuric acid, a very ſtriking proof of the ſtrong tendency of ammonia to unite with ſulphat of mercury, ſince the affinity of the mercurial ſalt for the alkali, aſſiſted by the conſequent inſolubility of the triple compound, is here ſufficient to overcome the affinity of the alkali for the acid with which it was previouſly ſaturated.

The ammoniaco-mercurial ſulphat has a pungent and ſtyptic taſte, is ſcarcely ſoluble in water, is partially (but not entirely) decompoſed by lime and the fixed alkalies, and is compoſed of 18 per cent. of ſulphuric acid, 33 of ammonia, and 10 of water, the remainder being oxyd of mercury. When heated to decompoſition, it gives out ammonia, azotic gas, running mercury, and a little ſulphite of ammonia.

The red and yellow oxyds of mercury are ſoluble in dilute ſulphuric acid when heated, but without the evolution of ſulphureous acid gas. When the ſolution is complete, it does not differ from thoſe made with this acid and metallic mercury.

The liquid ſulphureous acid has no action on reguline mercury. When poured on the red oxyd, the latter becomes immediately white, owing to a partial diſoxygenation, ſince at the ſame time the acid loſes its ſulphureous ſmell. If much of the acid is added, and the mixture be expoſed to the ſun's rays, the oxyd is reduced even to the metallic ſtate, and the liquor contains naked ſulphuric acid.

The nitric acid diſſolves mercury with great eaſe, with or without the aſſiſtance of heat, and various important combinations ariſe from the union of theſe ſubſtances. When mercury is put into cold nitric acid moderately diluted, a ſtrong mutual action begins immediately, but as long as no heat is uſed, very little nitrous gas is given out. After ſtanding ſome hours the acid becomes ſaturated, when it has diſſolved about as much mercury as there was of concentrated acid employed. This ſolution is very heavy, clear, and colourleſs; it ſtrongly corrodes animal and vegetable matters, and when evaporated it furniſhes very heavy nearly tranſparent cryſtals of nitrated mercury, the form of which varies extremely, according to the heat and other circumſtances of evaporation, but if this is performed ſlowly the cryſtals are often very large and beautiful, in the form of flattened truncated pyramids. As but little nitrous acid has been decompoſed in making this ſolution (only a ſmall quantity of nitrous gas having been given out) the metal is in a low ſtate of oxygenation, and the ſolution mixes with water without any turbidneſs. In this ſtate the pure fixed alkalies give a yellowiſh-white precipitate, and ammonia a greyiſh-black one.

But if (even with the ſame proportion of mercury to acid) a boiling heat has been uſed during the ſolution, nitrous gas is given out very copiouſly, and the ſolution when complete contains therefore the metal in a much higher ſtate of oxydation than in the cold ſolution, and a ſmaller relative proportion of acid. It is alſo much altered in its properties, for on dilution with water it lets fall a precipitate of a yellowiſh-white colour with cold, and orange-yellow with boiling water (nearly as the turbith is made with the ſulphat of mercury,) which precipitate is compoſed of nitric acid with a great exceſs of mercurial oxyd, and may be called the *inſoluble ſub-nitrat of mercury*. The difference between theſe two ſolutions was firſt noticed by Bergman in his valuable Eſſay on the Analyſis of Mineral Waters.[i] But when heat is uſed, the acid alſo becomes able to take up a much greater quantity of mercury, with this difference however, that if the ſolution be firſt made with heat, the diſengagement of nitrous gas ſtops long before the acid is ſaturated, ſo that the latter portion of mercury does not appear to decompoſe any nitric acid in order to be diſſolved, as Scheele has accurately obſerved. Nitric acid therefore, boiled on more mercury than it can diſſolve, is ſuperſaturated with mercurial oxyd, but as the laſt portion of mercury obtains no oxygen from the acid (otherwiſe nitrous gas would be given out) the queſtion is whence it derives the oxygen neceſſary to its ſolution. This Berthollet rationally explains by ſuppoſing that the firſt diſſolved portion, which when heat is uſed is left highly oxygenated, divides its oxygen with the laſt portion of mercury, ſo that the whole ſolution is equally oxygenated to a low degree. Hence it appears that there may be three ſaturated ſolutions of oxyd of mercury in nitric acid, each differing from the other, either in the reſpective proportions of metal and acid, or of oxygenation of the metal: namely, 1ſt, the ſolution made by ſaturating the acid with mercury without heat, which is the moſt acrid ſolution, cryſtallizes the moſt readily, and is not decompoſable by water: 2dly, the ſame ſolution heated, by which the metal becomes more oxygenated, the acid is in ſomewhat ſmaller proportion, and the ſolution depoſits the yellow nearly inſoluble ſub-nitrat by mere addition of water: and 3dly, the laſt-mentioned ſolution, ſuperſaturated with mercury at a boiling heat, by which the acid becomes loaded with metal, which, for the reaſons before-mentioned, is obviouſly leſs oxygenated than in the ſecond caſe, and perhaps leſs than in the firſt alſo.

The cryſtallized nitrat of mercury, when kept in contact with air gradually changes, and from being nearly tranſparent and colourleſs, becomes covered at its ſurface with a yellow mealy ſubſtance, which is found to reſemble exactly the yellow ſub-nitrat ſeparated from the ſolution made with heat, by the affuſion of water. Hence it appears that the cryſtallized metal gradually abſorbs oxygen from the air, and in ſo doing loſes its ready ſolubility in water. An exceſs of nitric acid oppoſes this ſpontaneous change.

With ammonia effects are produced on the nitrat of mercury ſomewhat ſimilar to thoſe on the ſulphat. If much of this alkali is added a copious black precipitate is produced, but if only in ſmall quantity the precipitate is grey. This is an ammoniaco-mercurial nitrat ſcarcely ſoluble in water, mixed with a black mercurial powder, nearly reduced to the metallic ſtate. The ſame grey precipitate is obtained by mixing nitrat of ammonia with nitrat of mercury. The ſolution yields by evaporation priſmatic cryſtals, compoſed, according to Fourcroy, of 68.2 of oxyd of mercury, 16 of ammonia, and 15.8 of nitric acid and water.

When the cryſtallized nitrat of mercury is expoſed to a heat gradually increaſing, the firſt effect is to drive off the water; after which a thick red nitrous acid vapour ariſes, part of which is condenſible by water, and the remainder is permanently elaſtic and flies off.

Dr. Higgins[k] found that on gradually diſtilling *per ſe* 34 ounces of dry white nitrat of mercury, about 8 ounces of acid and aqueous vapour were thus driven off, and nothing more would eſcape in a heat raiſed to about 600°. The reſidue is that red oxyd of mercury ſo generally known by the name of ***Red precipitate***, or *Red nitrous oxyd of mercury*.

This oxyd is manufactured in the large way, being one of the moſt important of the mercurial preparations, and when very well made it is of a very beautiful uniform orange-red, and of a gliſtening ſcaly texture. Much technical nicety ſeems required to enſure this uniformly beautiful appearance, but the preparation of it for every uſeful purpoſe is not a matter of any great difficulty. The London Pharmacopœia gives the following recipe: mix in a glaſs veſſel one pound of nitric acid, one pound of mercury, and one dram of muriatic acid, diſſolve the mercury in the acid by help of a ſand heat, then encreaſe the fire till the whole maſs changes into red cryſtals, which are the red precipitate. The uſe of the muriatic acid here is ſuppoſed to be to aſſiſt in giving the beautiful colour. The whole proceſs therefore conſiſts eſſentially merely in diſſolving the mercury in the acid, evaporating the ſolution to dryneſs (it is not neceſſary to wait for a regular cryſtallization) and then to continue the heat with a cautious increaſe till every red vapour and every thing volatile is driven off. The heat may be raiſed almoſt to redneſs, but not beyond, otherwiſe the red oxyd itſelf is decompoſed. It ſeems preferable after the nitrat of mercury is thoroughly dry, to complete the expulſion of the nitrous vapour and converſion into red oxyd, by heating the ſaline maſs in a broad veſſel over an open fire rather than in a ſand-bath, great care being taken to avoid breathing the fumes of the acid, which ſeem to carry away a ſmall portion of the metal, and are very noxious. As the nitrous acid here uſed generally contains a ſmall portion of muriatic acid, ſome corroſive ſublimate is alſo formed and volatilized in the drying, which much contributes to the noxious quality of the vapour.

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[i] Eſſays, vol. i. p 133.

[k] Minutes, &c. p. 40.

In the proportions above given equal parts of mercury and acid are taken, but this is more acid than is neceſſary, ſince a portion of undecompoſed nitrous acid is expelled during the drying. Fiſcher[1] aſſerts that in the common way of preparing this ſalt by heating the white cryſtallized nitrat, the acid is ſo far from being ſaturated that perfectly good precipitate may be made by rubbing this cryſtallized ſalt with its own weight of running mercury, (which thoroughly mixes with it in a very few minutes) and then heating as uſual till the whole becomes an uniform red maſs.

By this method a large portion of the acid is ſaved, but we cannot help doubting the perfect accuracy of the experiment. No harm, however, can ariſe from the uſe of an exceſs of nitric acid, ſince all the ſuperfluous part is loſt in the evaporation, and therefore on the whole it ſeems the beſt not to load the acid with much more than its own weight of the metal.

Red precipitate, well prepared, ſo cloſely reſembles the *precipitate per ſe*, or oxyd formed by ſimple calcination, already deſcribed, that there is little danger of error in adopting the uſual opinion that they are identically the ſame and are compoſed only of mercury and oxygen. The phenomena of their decompoſition too moſt cloſely correſpond, for when the red nitrous oxyd is heated to redneſs it gives out a copious ſtream of oxygen, and the metal diſtills over in its reguline ſtate, leaving at laſt not an atom of any ſubſtance in the diſtilling veſſel. The only known difference between the two (colour excepted, which is much the brighteſt in the red nitrous oxyd) is that the nitrous oxyd gives out, beſides oxygen, a certain portion of azotic gas, owing to the final decompoſition of the laſt adhering particles of nitrous acid.

The oxygen gas from this as from the other mercurial oxyds is always at firſt mixed with ſome mercury in vapour, and ſometimes with a minute portion of corroſive ſublimate, ſo that it is not fit for all the purpoſes of oxygen gas till it has ſtood for ſeveral hours in contact with water.

Nitrat of mercury in every ſtate of oxygenation is readily decompoſed by many other acids. If ſulphuric acid or any alkaline ſulphat be poured into liquid nitrat of mercury, a white precipitate is produced, which by waſhing becomes yellow, and is the ſub-ſulphat or turbith. If muriatic acid or any alkaline muriat is added, the precipitate is a white muriat, but under certain limitations which will be preſently mentioned.

There are two (and only two) combinations of mercury with the muriatic acid, forming ſalts of very different properties in every reſpect, both of which are of high importance in technical as well as experimental chemiſtry, and have engaged more of the attention of chemiſts than perhaps any other of the metallic ſalts. One of theſe is a very ſoluble cryſtallizable ſalt of a very acrid nauſeous taſte and a violent poiſon in any but ſmall doſes, which is prepared almoſt entirely by ſublimation, and is called *corroſive ſublimate*, or *corroſive muriat of mercury*, or at preſent by ſome, ſimply *muriat of mercury*, and by ſeveral of the French chemiſts, though incorrectly, *oxymuriat of mercury*. This ſalt conſiſts of muriatic acid and mercury oxydated to a high degree.

The other combination of mercury with the marine acid is a white powder with but little taſte, inſoluble in water, and prepared ſometimes by ſublimation, (by which method alone it is cryſtallizable) ſometimes in the moiſt way. It conſiſts of muriatic acid ſuperſaturated with mercury at a lower ſtate of oxydation than in the former ſalt; and may be prepared (as it often actually is) by combining the corroſive muriat with an additional portion of mercury in the metallic ſtate, whereby the ſame relative portion of acid is united with much more metal, and the oxygen of the ſalt diſtributes itſelf equally to the newly-added mercury, bringing the whole to a lower ſtate of oxydation. This latter preparation has received the various names of *mild mercurial muriat*, or

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[1] Scherer's Journal, or Phil. Mag. vol. xvii.

ſweet mercury (being much leſs active in its effects on the animal body than the former) and alſo *calomel*, by which name it is moſt known in medicine. To avoid confuſion we ſhall at preſent chiefly employ the terms *corroſive muriat*, and *calomel*, in deſcribing theſe different ſalts.

Mercury in the metallic ſtate is not acted on by the muriatic acid, either hot or cold, but when the metal is previouſly oxydated or diſſolved in an acid, the muriatic acid readily unites with it, and it is in this indirect way that the muriats of mercury are formed.

Corroſive muriat is prepared almoſt excluſively by the proceſs of ſublimation. All the materials neceſſary are; mercury, brought to a high degree of oxydation by previous ſolution in an acid; and muriatic acid in a ſtate fit to be diſengaged in the vaporous form; and the heat uſed for ſubliming expels both the mercury and the acid in union with each other, which on cooling cryſtallize into the corroſive ſalt.

One good method therefore of making this ſalt (which is often uſed) is the following. Diſſolve in a glaſs veſſel [m] 8 ounces of mercury in 10 or 12 ounces of nitric acid, evaporate this ſolution to perfect dryneſs, which leaves a white ſalt, the nitrat of mercury; rub this ſalt in a mortar not made of metal with 8 ounces of decrepitated common ſalt, and as much ſulphat of iron previouſly dried to a white powder by heat. When theſe materials are well mixed, put them into a matraſs, of which two-thirds are left empty, place it on a ſand-bath with the hot ſand juſt hiding the materials, and proceed to ſublimation with a heat gradually raiſed to redneſs, allowing the fumes to paſs off up a chimney, as they would be dangerous to breathe. When cold, break the matraſs carefully (which is better done if it is previouſly cracked round with a cold wet iron while ſtill hot) and ſeparate the white cryſtallized ſublimate from what remains at the bottom. The former is the corroſive muriat, the latter is a mixture of ſulphat of ſoda and oxyd of iron ariſing from the mutual decompoſition of the common ſalt and the ſulphat of iron. The ſole uſe of the ſulphat of iron is to afford ſulphuric acid, in order to diſengage the acid of the common ſalt in a vaporous form. The corroſive ſublimate formed in this operation is beautifully cryſtallized in needles if the heat be moderate, but if it be too great, the ſalt coaleſces into a ſingle cake compoſed of very ſmall cryſtalline particles.

In ſome of the large manufactories of this ſalt in Holland, the mercury is ſaid not to be previouſly diſſolved in nitrous acid but ſimply ground to fine powder along with the ſalt and vitriol of iron.

Whenever ſulphat of iron is employed, the ſublimate is liable to be contaminated with a portion of oxyd of iron, this metal being to the full as volatilizable by muriatic acid as the oxyd of mercury is, but the following ſimple and excellent proceſs firſt invented by Kunkel [n] excludes iron altogether.

Take equal weights of mercury and ſulphuric acid, diſtill the mixture to dryneſs till only the white ſulphat of mercury is left, mix this latter ſalt with about its own weight of common ſalt, rubbing the mixture well, and then ſublime in the way before mentioned. The ſublimate is very pure corroſive muriat of mercury, and the reſidue at the bottom of the veſſel is ſulphat of ſoda. The London Pharmacopœia has adopted this method: the proportions employed are two pounds of mercury, as much ſulphuric acid, and three pounds and a half of common ſalt. In preparing the ſulphat of mercury for this proceſs, the heating of the acid and the mercury muſt not be carried ſo far as to drive off any of the acid which properly belongs to the ſulphat of mercury, or in other words, the mixture muſt not be reduced to the ſtate of turbith, otherwiſe there will be no ſulphuric acid left to expel the muriatic acid from the common ſalt. But if turbith be employed ſome freſh ſulphuric acid muſt be added.

Another method nearly as economical as the former, is to grind up mercury, ſulphat of iron, common ſalt, and nitre, and then ſublime. Here both the nitrous and muriatic acids are driven from their baſes by the ſuperior affinity of the ſulphuric, and the mercury, firſt diſſolved by the nitrous acid, is afterwards united to the muriatic in the form of corroſive muriat when ſublimed.

A ſulphat of mercury fit for giving corroſive muriat by ſublimation with common ſalt is alſo formed very expeditiouſly by adding nitrated mercury to a ſolution of ſulphat of potaſh, when a white ſalt, the ſub-ſulphat of mercury, is precipitated, being very little ſoluble, and the clear liquor conſiſts chiefly of nitrat of potaſh formed by double affinity.

With regard to the actual quantity of ſublimate produced from a given proportion of materials, it has been found by an eminent practical chemiſt [o] that 16 ounces of mercury with 15 ounces of ſtrong ſulphuric acid (which is ſufficient) will yield about 23½ ounces of dry ſulphat of mercury, which, ſublimed with 30 oz. of dried muriat of ſoda, yield 20 oz. of corroſive muriat.

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[m] Beaumé.

[n] Bergman's Eſſays, vol. iii.

[o] Original communication.

Corroſive muriat may be prepared without ſublimation: the uſe of this latter proceſs being only to ſeparate the ſalt from the other materials which are not volatile at a low red heat. The following way is given by Von Schmidt:[p] diſſolve 2 ounces of mercury in 3½ oz. (a leſs quantity would be ſufficient) of ſulphuric acid, and diſtil to dryneſs in the uſual way. Add to the white ſulphat of mercury in the retort a ſolution of 5½ oz. of common ſalt, and boil the mixture for an hour, then filter the liquor while hot, and evaporate it to dryneſs. Add to the reſiduum (which now conſiſts of ſulphat of ſoda, corroſive muriat, and perhaps ſome undecompoſed common ſalt) about 16 oz. of alcohol, digeſt for an hour in a moderate warmth, and decant off the clear liquid. This is a ſolution of the corroſive muriat in the alcohol, the other ſalts being inſoluble in the ſpirit, and therefore remaining at the bottom. Then evaporate the alcoholic ſolution to dryneſs, which leaves the corroſive muriat as a perfectly white maſs which may be obtained in beautiful cryſtals by ſubſequent diſſolution in boiling water and cooling. To extract all the mercurial muriat from the maſs it will be adviſeable to repeat the proceſs with about 8 oz. more of alcohol, and proceed as before.

Corroſive muriat may alſo be made by direct ſolution and cryſtallization. If oxyd of mercury is mixed with water in a Woulfe's bottle, and a current of oxymuriatic acid gas be paſſed through for ſome time, a ſolution is formed, which gives by evaporation cryſtals of very pure corroſive muriat. In this manner the ſalt may be obtained of perfect purity.

The ſame product is formed when oxymuriatic acid is added to the nitrat of mercury either ſoluble or inſoluble in water; by evaporation the nitric acid flies off, together with the exceſs of oxymuriatic acid, and the corroſive muriat is obtained in very pure and regular cryſtals.

But if oxymuriatic acid be poured on running mercury it firſt reduces it to a grey powder without extrication of any gas, which powder is the ſame in nature as the mild muriat or calomel to be preſently deſcribed. But if an exceſs of the acid be ſo uſed this grey powder is diſſolved, and the ſolution is changed to corroſive muriat.

Corroſive muriat, in whatever way it be formed, is a ſalt which cryſtallizes, when formed by ſublimation, generally in long needles, but by watery ſolution it affects the form of four-ſided priſms. Its taſte is extremely acrid, nauſeous, and ſtrongly metallic, and ſo permanent that it is very difficult to get it off the palate. It is not deliqueſcent. Cold water diſſolves $\frac{1}{16}$ to $\frac{1}{20}$ of its weight of this ſalt, but boiling water much more. When heated moderately (but to a degree much above that of boiling water) it ſublimes in the form of a denſe white ſmoke moſt exceſſively prejudicial to thoſe that reſpire it. Light has a powerful effect on this ſalt. If it is expoſed to a ſtrong light it after a while becomes mealy on the ſurface, and if then thrown into boiling water the whole will not diſſolve as at firſt, but a reſidue of a dingy white colour ſettles to the bottom which is found to be calomel. Alſo when a clear ſolution of the ſalt is expoſed to the ſun's rays a ſimilar precipitation of a white inſoluble ſubmuriat takes place. Hence all ſolutions of this ſalt becomes muddy by keeping unleſs ſecluded from the light. M. Boulley[q] found that during this change oxygen was given out.

This ſalt is alſo ſoluble in alcohol, which when moderately warm takes up about $\frac{3}{8}$ of its weight.[r] Boiling alcohol diſſolves nearly its own weight, moſt of which ſeparates again on cooling.

Sulphuric acid[s] does not decompoſe this ſalt, but being poured on it, reduces it to a powder, ſimply owing to the abſtraction of its water of cryſtallization; for on adding water the powder is entirely rediſſolved. Nitrous acid added to this ſalt diſſolves it when heated and lets it go on cooling, unaltered. The muriatic acid diſſolves this ſalt, but renders it leſs eaſily cryſtallizable.

All the alkalies and alkaline earths decompoſe corroſive ſublimate. The fixed alkalies and alkaline earths when cauſtic give a precipitate, at firſt orange, which afterwards deepens into a brick red. But the carbonated alkalies produce a precipitate of a much lighter ſhade of colour. Corroſive muriat and alkalies therefore are mutually a teſt for each other, and are often uſed as ſuch.

The action of ammonia on this ſalt is ſingular. With the other ſolutions of mercury ammonia gives a black powder, which is the metal almoſt reduced to a metallic ſtate, as already mentioned, but when this alkali is added to a ſolution of corroſive muriat a copious *white precipitate* falls down, which remains white after deſiccation. Fourcroy found that 100 parts of the muriat ſuperſaturated with ammonia gave 86 parts of white precipitate, whereas cauſtic ſoda gave only 75 of brick-red oxyd. The white precipitate therefore contains ſomething beſides oxyd of mercury. It was inſoluble in water, and when diſtilled per ſe in a retort it gave out ammonia, azotic gas, and 86 per cent. of calomel was left. By further analyſis Fourcroy found this white precipitate to conſiſt of 81 of oxyd of mercury, 16 of muriatic acid, and 3 of ammonia. It is therefore a triple compound, but rendered inſoluble by the great exceſs of mercury. Sulphuric acid converts it to corroſive muriat and ammoniaco-ſulphat of mercury. Muriatic acid rediſſolves this precipitate, and produces the ſame ſalt as is formed by the addition of muriat of ammonia to corroſive muriat, and which is of a very peculiar nature.

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[p] Van. Mons Journ. or Phil. Mag. Vol. xvi.
[q] Ann. de Chem. tom. lxiv.
[r] Eſſays Vol. iii.
[s] Bergman.

When mercury, muriatic acid, and ammonia are in a ſtate of mutual ſaturation without decompoſition, (as happens when muriat of ammonia is added to corroſive muriat) a moſt intimate combination takes place between the three ſubſtances, and the mercurial muriat by help of the ſal ammoniac is rendered full twenty times more ſoluble in water than before, for one part of ſal ammoniac diſſolved in 3 of water, will enable the latter to diſſolve no leſs than 5 parts of the mercurial ſalt when the temperature is raiſed. This triple combination is not broken by ſublimation, for the ſalt that riſes in this proceſs ſtill contains ammonia and is equally reſoluble in a ſmall proportion of water. This triple ſalt, long known to the older chemiſts was called by them *Sal alembroth.* In modern nomenclature it is termed *the ammoniaco-mercurial muriat.*

If to the ſolution of this ſalt (formed by equal weights of muriated ammonia and corroſive muriat) be added a carbonated fixed alkali, an effervеſcence takes place, and a white precipitate is formed, ſimilar to that produced by ſuperſaturating corroſive muriat with ammonia, which, as already mentioned, ſtill conſiſts of muriatic acid, ammonia, and oxyd of mercury, but the latter ſo much in exceſs as to be rendered inſoluble. This is the common *white precipitate* of pharmacy, which muſt be carefully diſtinguiſhed from the ſimple ſub-muriat or calomel. If however too much fixed alkali be added, the precipitate is yellow. Eight parts of corroſive muriat will yield about 7¼ of white precipitate.

The exact compoſition of corroſive muriat will be mentioned after deſcribing the mild muriat or calomel.

Corroſive muriat is one of the moſt active mercurial medicines, and is one of the moſt violent poiſons in an over-doſe, of all the metallic ſalts, inflaming and diſorganizing the whole alimentary canal. But it preſerves dead animal matter very perfectly, which when waſhed with a ſaturated ſolution of the ſalt and expoſed to the air is ſoon covered with a ſaline cruſt or varniſh which no inſect can touch.

The next combination of mercury with muriatic acid to be mentioned, is the *Sub-muriat, mild or ſweet Muriat, or Calomel.* It differs from corroſive ſublimate not in the number and nature of its conſtituent parts but only in their proportion, and is found by numerous experiments to contain in equal weights more mercury, or, (what is the ſame thing) leſs acid, and the mercury leſs oxydated. Theſe two circumſtances will explain the many caſes of the mutual converſion of the one ſalt into the other, and production of one from the other by various chemical agents.

The ſub-muriat is made in two ways, either by precipitation from ſolution, or by ſublimation. The latter is the moſt antient, and is thus performed. Take one pound of corroſive ſublimate and nine ounces of running mercury, rub them in a mortar with juſt water enough to prevent the ſublimate from flying off in duſt till the whole becomes a grey powder, and no globules of mercury can any longer be perceived. Put this powder into one or more glaſs ſubliming veſſels (common phials will anſwer in the ſmall way, which ſhould be no more than half full) and ſet them on a ſand bath covered up to the beginning of the neck with the hot ſand, and ſublime with a heat gradually increaſed. The firſt ſubliming of the calomel is perceived by a white vapour which iſſues from the mouth of the veſſel. The calomel is not pure after the firſt operation, for a ſmall portion of undecompoſed mercury and of corroſive ſublimate firſt riſe and occupy the top of the veſſel. Below this is a white cake, which is the true ſub-muriat, and at the bottom of the veſſel remains a ſmall quantity of reddiſh oxyd which cannot be ſublimed. The whole contents of the ſubliming veſſel are then to be rubbed together and again ſubmitted to the ſame proceſs, and when finiſhed the cake of calomel which occupies the middle of the veſſel is to be carefully ſeparated and waſhed repeatedly with hot water to free it from any adhering particles of corroſive ſublimate.

Some chemiſts have thought proper to repeat the ſublimation of calomel for five, ſix, or more times (ſeparating after each time the white powder that riſes firſt and fixes to the top of the bottles) with a view of more compleatly combining the ſublimate with the mercury and rendering it a more uniform and ſafer medicine. But it is clearly ſhewn that no good whatever can ariſe from ſuch frequent ſublimation, but on the contrary, the calomel every time becomes in ſome degree decompoſed and its properties injured.

Calomel nine times ſublimed forms what has been called by ſome the *Mercurial Panacea.*

The ſub-muriat of mercury is a white ſolid maſs ſometimes cryſtallized in tetrahedral priſms when ſlowly ſublimed. It differs moſt eſſentially from corroſive ſublimate in many ſenſible and chemical properties. It is nearly, if not entirely inſoluble in water, it has but little taſte, but what there is is metallic and nauſeous, it becomes yellowiſh by long expoſure to light and is luminous when rubbed in the dark. It requires a greater heat to be ſublimed than the corroſive muriat does, whence after ſublimation of a mixture of the two, the upper portion is chiefly the corroſive muriat and the lower part is the calomel. When lime-water or the alkalies are added to calomel it immediately blackens, which circumſtance is a very uſeful teſt for this ſubſtance.

The ſub-muriat may alſo be prepared in the moiſt way and without ſublimation by adding nitrat of mercury to muriat of ſoda. A double decompoſition takes place here, the muriatic acid uniting with the mercury into the ſub-muriat (which being inſoluble in water falls to the bottom) and the nitric acid and ſoda of the ſalt remain united in the liquor. For this proceſs we are indebted to the illuſtrious Scheele, whence the preparation is ſometimes called Scheele's Calomel. It is thus made. Take a ſolution of mercury in nitrous acid ſo ſtrong as to be perfectly ſaturated even while boiling. For this about ſix ounces of acid, and as much mercury may be uſed. Then pour the ſolution rather gradually into another veſſel containing four ounces of common ſalt diſſolved in half a pint of boiling water.

When the white ſub-muriat has entirely ſubſided, pour off the ſupernatant liquor and waſh the precipitate thoroughly with warm water, then dry it in a gentle heat.

The ſub-muriat prepared in this way ſcarcely if at all differs from the calomel formed by ſublimation, being equally inſoluble in water, blackened by lime-water, and ſhewing all the other properties of calomel. This precaution however is to be obſerved, which is, that as the nitrous ſolution when loaded with mercury (as in the preſent caſe) is in part decompoſable by mere water, it ſhould be dropped gradually into the ſolution of ſalt with frequent ſtirring, (and not the ſalt added to the nitrat as directed by ſome) and alſo, as Mr. Chenevix has obſerved, it will more entirely ſecure the decompoſition of the nitrat if a little muriatic acid be added to the ſolution of common ſalt before it is uſed. The ſub-muriat thus prepared may alſo if neceſſary be afterwards ſublimed, and it will be found to riſe in the ſubliming veſſel almoſt without any reſidue.

Mercury is not known to exiſt in any other form of combination with muriatic acid than as corroſive muriat and ſub-muriat, no intermediate ſtate of ſaturation with the acid having been ever obſerved, and as before mentioned, the difference between the two ſalts is, that the corroſive muriat contains more acid than the ſub-muriat, leſs mercury, and the mercury is in a lower ſtate of oxygenation. A number of facts have been obſerved by chemiſts relating to the mutual change of one of theſe ſalts into the other by different reagents ſome of which may be mentioned.

Beaumé endeavoured to form ſome intermediate muriat of mercury both by mixing and ſubliming proportions of corroſive ſublimate and running mercury, different from thoſe that conſtitute calomel, and by mixing corroſive muriat and calomel and ſubliming, but in no inſtance was there produced any thing but corroſive muriat and calomel.

The proportion of ſub-muriat produced in Scheele's method depends on the degree in which the nitric acid is ſaturated with the mercury. If an exceſs of acid remains, but little calomel is produced on adding the common ſalt, and the ſolution contains corroſive muriat.

The mercury in calomel is leſs oxygenated than in corroſive muriat, and many curious experiments have been made illuſtrating this fact. Thus, as Prouſt obſerves, if muriatic acid be boiled on calomel, corroſive muriat is formed, and ſome running mercury appears, ſo that the calomel is divided into two portions, one of which takes the oxygen belonging to both and unites with the acid into corroſive muriat, and the other therefore is reduced to the metallic ſtate.

Luſſac found that on mixing corroſive ſublimate and red oxyd of mercury, and ſubliming, if the heat was moderate the corroſive muriat roſe in the veſſel unaltered, but at a low red heat, calomel was produced. Now as the red oxyd parts with its oxygen at this heat, the remaining mercury muſt have been reduced to the metallic ſtate, and thus by combining with the corroſive muriat produced the calomel.

The precipitate from nitrat of mercury by potaſh or ſoda gives no calomel when combined with corroſive muriat and ſublimed at a moderate heat, as Cornette has obſerved:[p] but when the precipitate from nitrated mercury by *ammonia* is uſed, a large quantity of perfect calomel is procured.

This experiment, Cornette very ſatisfactorily explains by ſhewing the different nature of the precipitate by ammonia from thoſe by the fixed alkalies, and the property of the volatile alkali to reduce metallic oxyds to their reguline ſtate.

The deoxydating power of muriat of tin ſhews in a ſatisfactory way the reſpective compoſition of corroſive muriat and calomel.

Muriat of tin (as will be mentioned under that article) when ſaturated with metal has the power of depriving mercurial ſolutions of their oxygen and reducing them to the metallic ſtate.

When *a few drops* of muriat of tin[q] are added to a ſolution of corroſive muriat, a whitiſh yellow powder is obtained which agrees in every property with calomel; if a little more of the tin is added, the powder becomes grey, and on examination by the microſcope is found to be globules of running mercury. But if a large quantity of muriat of tin is added at once to the corroſive muriat, the intermediate ſtate of calomel is not produced, and the mercury at once aſſumes the reguline form.

When nitrous acid is added to calomel, a copious diſengagement of nitrous fumes takes place, (which does not happen with the perfect oxyds of mercury) the calomel is diſſolved, and the ſolution diſtilled to dryneſs gives a white ſaline maſs. This, heated in a cloſe veſſel gives about half its weight of a cryſtallized ſalt which ſublimes at the upper part of the veſſel and is corroſive muriat. The remainder when further heated, emits abundant red fumes, changes colour, and at laſt is converted into the red oxyd of mercury.

It has been ſuppoſed by ſome chemiſts of eminence, that the acid of corroſive ſublimate was the oxy-muriatic, or in other words, that a part of the oxygen which is contained in this ſalt is united to the acid and not to the mercury. As long as they are actually in combination it is not eaſy (if at all poſſible) to make this diſtinction, but it is certain that whenever the acid is ſeparated from the ſalt it appears in the form of the ſimple muriatic, and not the oxy-muriatic. Mr. Chenevix's experiments[r] on this head are deciſive, as will be further mentioned under the article *Oxymuriatic Acid*. When the ſulphuric acid is added to corroſive muriat, no acid fumes are diſengaged, whereas if the acid were the oxymuriatic, it would probably be ſet at liberty. Likewiſe when corroſive muriat is decompoſed by potaſh, the reſult is ſimply oxyd of mercury and *muriat* of potaſh, not *oxymuriat*. Nitrat of ſilver alſo gives a precipitate of ſimple muriat of ſilver or luna cornea.

To determine the compoſition of corroſive muriat and of calomel, Mr. Chenevix firſt decompoſed 100 grains of corroſive muriat by nitrat of ſilver to eſtimate the muriatic acid, and another 100 grains by potaſh for the oxyd of mercury, and thus found the conſtituents of corroſive muriat to be 82 per cent. of oxyd of mercury, and 18 of muriatic acid. To find out the degree of oxygenation of the metal, another portion of mercury was diſſolved in nitric acid, to which was added muriatic acid, and the whole was then evaporated to dryneſs, and ſublimed. A hundred grains of mercury thus treated gave 143.5 of corroſive ſublimate, whence (the quantity of acid in this ſalt being previouſly known) the reſpective quantities of mercury and oxygen were aſcertained, and it appears that the metal is here oxydated at the rate of 15 of oxygen in 100 of oxyd. Calomel was then treated in a ſimilar way, being firſt diſſolved in nitric acid and decompoſed by nitrat of ſilver to determine the quantity of muriatic acid, whence it was found to conſiſt of 88.5 of oxyd of mercury, and 11.5 of muriatic acid. To find the ſtate of oxydation in calomel, a given portion was boiled with nitro-muriatic acid, evaporated to dryneſs, and ſublimed, by which it was totally converted into corroſive muriat, and, by comparing theſe data with known proportions of the corroſive muriat before aſcertained, Mr. C. found the metal in calomel to be oxydated at the rate of only 10.7 of oxygen in 100 of oxyd, whereas that of corroſive muriat is 15 in 100.

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[p] Mem. de l'Acad. for 1786.

[q] Prouſt J. Phys. Tom. 59. p. 337.

[r] Phil. Trans. for 1802.

A hundred parts of calomel therefore contain

Mercury	79	88.5
Oxygen	9.5	
Muriatic acid		11.5
		100.0

A hundred parts of corroſive muriat contain

Mercury	69.7	82
Oxygen	12.3	
Muriatic acid		18
		100.

Mr. Chenevix in aſcertaining that corroſive ſublimate was not oxymuriat of mercury, but merely muriat of mercury highly oxydated, has diſcovered a ſalt which is truly the oxymuriat of this metal. By paſſing a current of oxymuriatic gas through water in which there was ſome red oxyd of mercury, after a time the red oxyd became of a very dark brown colour, and part of it was diſſolved. The liquor was then evaporated nearly to dryneſs and a mixed ſalt was obtained, conſiſting partly of corroſive muriat, and partly of another ſalt which cryſtallized later than the former, and on being rediſſolved and cryſtallized appeared nearly pure. This ſalt has not been much examined, but it poſſeſſes the eſſential quality of an oxymuriat in giving out vapours of oxymuriatic acid by the affuſion of the ſulphuric or any ſtronger acid.

The action of moſt of the other acids on mercury has been examined, but few of the ſalts are intereſting.

The acetous acid has no action on mercury, but if boiled on its oxyds it diſſolves them, though with difficulty. But the beſt and moſt effectual way of making the acetited mercury is by the double decompoſition of nitrated mercury and acetited potaſh. For this purpoſe take 3 ounces of mercury,[f] diſſolve it in about 4½ oz. of nitric acid or a little more than is ſufficient for ſolution without heat. Mix this with 3 oz. of acetite of potaſh previouſly diſſolved in 8 pounds of boiling water and ſet the whole aſide to cryſtallize, which takes place as the liquor cools, and the acetited mercury then ſeparates in the form of fine ſoft micaceous cryſtalline plates, very light and ſpungy. Then waſh them with cold water and dry them by paſſing between folds of blotting paper.

In preparing this ſalt it is eſſential to pour the mercurial ſolution into the acetite, otherwiſe part of the nitrat of mercury would be decompoſed by the mere water of the ſolution, and an inſoluble ſub-nitrat would be mixed with the acetite. The quantity of water of ſolution here directed is ſufficient to diſſolve, when boiling, both the acetite of mercury and the nitrat of potaſh; but the proceſs ſucceeds as well if only a few ounces of water are uſed, ſufficient to diſſolve the new formed nitrat of potaſh, in which caſe the whole acetite of mercury is precipitated and may be ſeparated and ſubſequently rediſſolved and cryſtallized. Neither is it neceſſary to uſe the cryſtallized acetite of potaſh, diſtilled vinegar nearly ſaturated with potaſh anſwering all the purpoſe.

Acetited mercury is ſcarcely ſoluble in cold water, but readily diſſolves as the heat is raiſed. The dry ſalt is eaſily decompoſed by heat.

The carbonic acid only unites with mercury when an acid ſolution is precipitated by a carbonated alkali. The carbonated oxyds are white and remain ſo unaltered by the air.

The boracic acid may be made to unite with mercury in the ſame way as the acetous acid, that is by double decompoſition. For this purpoſe common borax muſt firſt be neutralized with its own acid, then diſſolved in water, and nitrated mercury poured into it. The borat of mercury partly ſeparates on the firſt mixture of the liquor, and more may be obtained by evaporation. This ſalt is in the form of brilliant ſcales, which grow yellow by expoſure to air.

The phoſphat of mercury is formed in the ſame way as the laſt, by adding nitrat of mercury to an alkaline phoſphat. A white precipitate is formed which is phoſphat of mercury nearly inſoluble.

When the nitrat of mercury is decompoſed by alcohol, a very ſingular powder is produced, which appears to be the oxalat of this metal, and poſſeſſes a moſt aſtoniſhing power of exploſion when kindled, as diſcovered by Mr. Howard. This fulminating mercury will be deſcribed in the next article.

None of the alkalies have any action upon mercury, but the fixed alkalies diſſolve its oxyds. Theſe combinations have been but little examined.

Ammonia added to any of the mercurial oxyds immediately blackens them, cauſes the diſengagement of azotic gas, and reduces them nearly to the metallic ſtate. Fourcroy alſo aſſerts that another action takes place, namely, the production of a quantity of nitric acid by means of part of the azot of the decompoſed ammonia, which acid, as ſoon as formed, ſeizes on part of the ammonia and part of the mercury, producing the ammoniaco-mercurial nitrat already deſcribed.

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[f] Pharm. Edinb.

Mercury is capable of combining with ſulphur under various circumſtances and in different proportions; and as the rationale of theſe proceſſes has excited no ſmall controverſy among ſome of the ableſt modern chemiſts, we ſhall endeavour to give a clear and full ſtatement both of the facts and opinions belonging to this intereſting ſubject.

If one part of mercury and three parts of flowers of ſulphur are triturated together in a mortar, the globules of metal by degrees diſappear and combine with the ſulphur into a dark grey powder, which becomes more and more deep coloured the longer the trituration is continued. When the ingredients are ſo accurately ground together that no more globules of mercury can be diſtinguiſhed by the naked eye, mere expoſure to the air without any further trituration will at length render the powder perfectly black: in this ſtate it was known to ancient chemiſts by the name of *Ethiops mineral.* This ſubſtance, from its colour and from its becoming more and more black by expoſure to the air, is ſuppoſed by Fourcroy and certain other modern chemiſts, to be a compound of ſulphur and black oxyd of mercury. But this opinion ſeems to be entirely deſtitute of foundation; for if the ſulphur and mercury in the requiſite proportions be put into a dry vial and cloſely corked, and afterwards ſhaken vigorouſly for about a quarter of an hour, a perfectly black ethiops will be produced, and yet the incloſed air upon examination will be found to be neither altered in bulk nor deprived of any oxygen. The mercury and ſulphur in this ethiops are ſuppoſed to be much more looſely combined than in the ethiops made by heat, becauſe if the former is rubbed upon gold it will whiten its ſurface, which the latter is incapable of doing; this effect however may well happen from the minute uncombined globules of metal with which the ethiops generally abounds, rather than from the actual decompoſition of that portion which has united with the ſulphur.

But although mercury and ſulphur are capable of uniting with each other at the uſual atmoſpheric temperature, yet the combination takes place much more rapidly, and a ſmaller proportion of ſulphur is neceſſary for the ſaturation of the mercury, if both the ingredients are preſented to each other in a liquid ſtate. For this purpoſe let any quantity of ſulphur be melted in an earthen pot, and an equal weight of mercury be then added, care being taken to mix the two ſubſtances by accurately ſtirring them with a tobacco-pipe, or any other convenient inſtrument; an immediate combination will then take place, the maſs will become black and hot even to inflammation, (which however muſt be extinguiſhed as ſpeedily as poſſible, leſt a loſs both of ſulphur and metal be ſuſtained). When no more globules of mercury are perceptible let the veſſel be removed from the fire and its contents allowed to cool, ſtirring them all the while. The reſulting compound is in the form of ſmall hard black lumps, and is called *Ethiops mineral prepared by fire.* It differs from the preceding in containing leſs ſulphur, and when rubbed upon gold, does not whiten it, probably on account of its holding no uncombined mercury.

There is a third ſpecies of ethiops mineral prepared like the preceding by fuſion, but differing materially in the proportion of its ingredients; for, whereas the former contains equal parts of ſulphur and mercury; in this the ſulphur does not exceed 20 per cent. of the whole maſs. In conſequence of this exceſs of mercury, more time and a higher heat are required to accompliſh the combination, and it is attended by a remarkable evolution of flame at the moment of combination, that renders it unſafe to make uſe of cloſe veſſels for this purpoſe. Beaumè[t] relates, as the reſult of his own experiments, that the common ethiops may be prepared at the loweſt heat at which ſulphur becomes fluid, and that the combination takes place in perfect quiet: but when the materials are employed in the proportion of the latter mentioned ethiops, a conſiderable part of the mercury will remain uncombined, except at a temperature equal to that in which ſulphur becomes glutinous: while the union is taking place the maſs heats ſpontaneouſly, and a jet of flame is diſengaged. The colour of this ethiops is a dark violet; and by ſublimation at a red heat it becomes of a browniſh blood colour when in maſs, but when levigated it exhibits a bright crimſon, verging more or leſs upon ſcarlet. In this ſtate it is called cinnabar or vermillion, and probably differs in nothing but its ſuperior purity from the native cinnabar.

The prepared cinnabar being much preferable to the native as a pigment, has long been a conſiderable article of chemical manufacture, and as the Dutch have the reputation of making the beſt, we ſhall here deſcribe their method of proceeding, as related by M. Tuckert.[u] This manufacture conſiſts of two diſtinct operations, the one being the preparation of the ethiops, the other the converſion of the ethiops into cinnabar. To make the ethiops, a boiler of iron poliſhed on the inſide, and about 2½ feet in diameter, and 1 in depth, is charged with 1080 lbs of mercury, and 150 lbs of ſulphur (or *per cent.* 87.8 mercury, and 12.2 ſulphur) a moderate heat is then applied gradually increaſing, and accompanied by ſuitable ſtirring of the ingredients till the whole appears to be thoroughly mixed and combined. The black ſulphuret of mercury thus formed, is then removed from the boiler and pulverized. In order to convert this into cinnabar, three large earthen ſubliming pots are placed in a furnace, and gradually brought to a red heat by means of turf: at this time the cover of each (which conſiſts of a ſimple ſquare plate of iron) is removed, and the contents of an earthen veſſel holding about a pint and a half of ethiops, are poured into each pot. In a few ſeconds a column of flame riſes out of the pots, to the heighth of five or ſix feet, and, as ſoon as it begins to leſſen, the further eſcape of the contents is prevented by putting on the iron cover. In a ſhort time after, a ſecond charge is poured in, to which ſucceeds a third, and ſo on, till at the end of thirty-four hours the whole of the ethiops has been equally divided between the three pots, making 410 lbs. for each. The fire is now kept up as ſteadily as poſſible for thirty-ſix hours longer, in order to accompliſh the ſublimation, care being taken to ſtir up the materials at the bottom of the veſſels at leaſt once every half hour, by an iron rod made for the purpoſe and introduced at the top. At the ſame time the workman aſcertains how the proceſs is going on by the flame which appears when the cover is removed; if it riſes to the heighth of two or three feet, the heat is too great, as on the other hand it is too feeble if the flame only lightly quivers about the mouth of the pot; the proper temperature is marked by the flame riſing vigorouſly, yet not exceeding three or four inches in heighth. When the laſt thirty-ſix hours are expired, the furnace is extinguiſhed, and the whole allowed to cool: the ſubliming pots are then taken out, the iron hoops with which they are bound are knocked off, and the pots themſelves are broken; the cinnabar is found ſublimed in the upper part of the veſſel to the amount of 400 lbs. being 10 lbs. leſs than the ethiops that was put in: or in other words, the loſs of weight ſuſtained by the converſion of ethiops into cinnabar, amounts to 2⅛ per cent.

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[t] Chem. Experiment. ii. p. 459.

Cinnabar when re-ſublimed undergoes no alteration except that a variable though large proportion is loſt, owing to the combuſtion of the ſulphur and volatilization of the mercury. If cinnabar inſtead of being heated in cloſe veſſels, is put into an earthen teſt, and heated nearly to obſcure red, a total decompoſition takes place; the ſulphur is converted into ſulphureous acid, and the mercury flies off in the ſtate of vapour. Long expoſure to air and moiſture ſeems to have no ſort of action on cinnabar or ethiops; but they are both decompoſed by dry diſtillation with barytes, lime, and the fixed alkalies, and with the following metals, iron, copper, tin, lead, ſilver, cobalt, nickel, biſmuth and antimony. In all theſe caſes the ſulphur of the cinnabar combines with the added alkali or metal, while the mercury paſſes over in the liquid ſtate.

A remarkable circumſtance attending the decompoſition of cinnabar by iron filings, is the production of an odour reſembling that of ſulphuret of ammonia according to Sage, and of ammonia according to Beaumé: this odour is ſo ſtrong and permanent in the balloon receiver of the diſtillatory apparatus, that it remains very perceptible for ſeveral days, even though the veſſel is expoſed to the open air. The ammonia however thus developed, is in all probability neither formed by this proceſs nor liberated from the cinnabar, but from the iron filings, for, according to the intereſting experiments of Dr. Auſtin (ſee AMMONIA, p. 67) it is readily generated by expoſing moiſt iron filings to an azotic atmoſphere.

In the moiſt way none of the acids have any action on cinnabar, except the concentrated ſulphuric and the nitric: the former oxygenates the mercury and converts it to ſulphat, ſulphureous acid being diſengaged; the latter oxygenates both the mercury and the ſulphur, nitrous gas being given out, and ſulphat of mercury being the reſult.

If a ſolution of either of the fixed alkalies in a perfectly cauſtic ſtate, is boiled almoſt to dryneſs upon pulverized cinnabar, an extremely nauſeous odour is diſengaged, the alkali becomes more or leſs charged with ſulphur, and globules of running mercury are produced.

The component ingredients of ſublimed cinnabar are mercury and ſulphur, in the conſtant proportion, according to Prouſt,[x] of 85 of the former to about 14.5 of the latter. This reſult was obtained by decompoſing cinnabar by means of reguline antimony, a method in ſome reſpects preferable to the more uſual one by iron filings, eſpecially on account of the ready fuſibility of the ſulphuret of antimony.

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[u] Ann. de Chem. iv. p. 25.

[x] Journ. de Phyſ. liii. p. 92.

Some attempts have been made to prepare cinnabar by ſubſtituting the oxyds and even the ſalts of mercury to the ſimple metal, but for the moſt part with no improvement in the colour of the cinnabar, and at the imminent hazard of occaſioning a violent exploſion. Bayen was the firſt chemiſt who obſerved the fulminating property of the oxyds of mercury when heated with ſulphur, and theſe mixtures have hence received the name of Bayen's fulminating mercury. The moſt powerful of theſe mixtures is thus prepared:[y] to a ſolution of nitrat of mercury add limewater, as long as any precipitate falls down, decant the clear liquor and waſh the pulverulent oxyd with repeated portions of water, after which dry it on a water bath, and then grind it carefully in a mortar, with $\frac{1}{6}$ of its weight of flowers of ſulphur. This powder when laid on a hot iron explodes with conſiderable force, no doubt in conſequence of the ſudden deoxydation of the mercury and the rapid combuſtion of part of the ſulphur: for if it is performed in a cloſe veſſel to prevent the diſſipation of the powder, the reſult of its decompoſition will be a reddiſh violet coloured ſulphuret, ſimilar to that procured in the uſual manner. Corroſive muriat of mercury rubbed up with the ſulphur produces in like manner a violently exploſive compound, while on the other hand calomel and ſulphur afford by dry diſtillation cinnabar and corroſive muriat without any exploſion; the reaſon of which is that the calomel divides itſelf into two portions, of which one is converted into cinnabar by combining with the ſulphur and letting go its oxygen and muriatic acid, which being abſorbed by the other portion of calomel, convert it into corroſive ſublimate.

Sometimes cinnabar is prepared in the laboratory, though not in the large way, from corroſive ſublimate and ſulphuret of antimony, by diſtilling them together in the proportion of three of the former to one of the latter: in this caſe a double decompoſition takes place; the oxygen and muriatic acid of the mercurial ſalt combine with the antimony, while the ſulphur of this laſt unites with the mercury: hence during the proceſs the products appear in the following order; firſt, the corroſive muriat, or butter, of antimony, paſſes into the receiver, then ſome undecompoſed corroſive ſublimate makes its appearance, and laſtly, at a red heat, the cinnabar riſes and attaches itſelf to the neck of the retort.

The action of mercury and its oxyds in the moiſt way upon the alkaline ſulphurets, hydroſulphurets, and hydroguretted ſulphurets, is very ſtriking, and has received much attention from various chemiſts, though from the natural intricacy of the inquiry many difficulties yet remain to be cleared up.

It was an obſervation by Schultz,[z] in the German Ephemerides, that firſt of all we believe attracted the attention of chemiſts to this ſubject. He obſerves that if 36 grains of mercury be put into an ounce vial, with half an ounce of Boyle's fuming liquor, for a few days, and is frequently ſhaken during the interval and occaſionally expoſed to a gentle heat, the mercury will become at firſt black, and after a while will be wholly changed into cinnabar; when this has taken place, the ſupernatant liquor will be found to have loſt its odour and colour, and will be covered with a ſaline pellicle. Hoffman and Wiegleb verified this obſervation and ſupported it by ſome new experiments, to which Beaumé ſoon after made ſome very valuable additions. He put into a vial ſome mercury with twice its weight of volatile liver of ſulphur; upon agitating the mixture the mercury was immediately converted into a black powder, which three days after was found to have aſſumed the appearance of cinnabar, and cryſtallized in thick and very ſhort priſms. 2. Sulphat of mercury being mixed with volatile liver of ſulphur, a conſiderable heat and ebullition was produced, and the mercury became black; three days after, the ſupernatant liquor now colourleſs was poured off, and a freſh portion of liquid ſulphuret was added, in the ſpace of two days more the precipitate was changed into cinnabar. 3. To a ſolution of nitrated mercury volatile liver of ſulphur was added as in the former caſes, a conſiderable heat was produced and a copious black precipitate fell down, which in the ſpace of a week had acquired a brick colour; the clear liquor was then poured off, and replaced by a freſh quantity of ammoniacal ſulphuret, by which in the ſpace of a few hours the colour of the precipitate was raiſed to a bright ſcarlet, fully equal to that of the beſt ſublimed cinnabar. 4. A mercurial ethiops was made in the uſual way by melting together four parts of mercury and one of ſulphur, this was pulverized and put in a vial with volatile liver of ſulphur, by which in the ſpace of half an hour it was converted into fine cinnabar. Similar effects to the above were obſerved to take place when a fixed alkaline liver of ſulphur was made uſe of, only the change of colour from a black to red was conſiderably ſlower, and the colour itſelf was leſs pure and brilliant. The laſt improvement in the preparation of cinnabar in the moiſt way, was made by M. Kirchoff, of Peterſburgh, and Count Mouſſin Pouſchin.[a] Three hundred grains of mercury and 68 grains of ſulphur, are to be triturated in a porcelain cup with a glaſs peſtle, a few drops of cauſtic potaſh being added to expedite and perfect the combination of the two ingredients: when a perfect ethiops is thus formed, there is to be added 160 grains of potaſh diſſolved in an equal quantity of water, and the cup with its contents is to be heated over a lamp, care being taken to continue without interruption the trituration with the glaſs peſtle. In proportion as the liquid evaporates freſh water muſt be added ſo that the ethiops may be conſtantly covered nearly to the depth of an inch. In the ſpace of about two hours the colour begins to change from black to brown, and then no more water is to be added, but the trituration is to be continued as before. As ſoon as the maſs acquires a gelatinous conſiſtence the colour becomes more red and brighter with great rapidity: this is the moſt critical point of the whole proceſs; for if the heat is not continued a ſufficient length of time the utmoſt perfection of colour is not attained, and if it is perſiſted in only two ſeconds too long, the tint is degraded to a dirty brown, incapable of being amended.

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[y] Sage Elem. de Mineral. ii. p. 58.

[z] Coll. Acad. vi. p. 30.

Thus far the preparation in the moiſt way of this beautiful colouring ſubſtance was carried by M. Kirchoff, to which the following important additions were made by Count Mouſſin Pouſchin. Firſt, the cup with its contents ſhould be removed from the lamp or ſand bath before the cinnabar has acquired its full degree of redneſs, and kept for three or four days at a temperature of 100° Fahr. ſtirring it up and adding a little water from time to time; at the expiration of this period the maſs being allowed to become nearly dry, will be found to have acquired all the vividneſs which the ſucceſsful accompliſhment of Mr. Kirckhoff's proceſs could have produced without the riſk of deſtroying it by too long continuance of the heat. In order to ſeparate the alkaline ſulphuret from the cinnabar, it muſt be mixed with boiling water in the proportion of about a quart of the latter to an ounce of the former: after ſtirring the whole up for a few ſeconds the water will become quite black, and is to be poured off as ſoon as the cinnabar has ſubſided: the edulceration is to be compleated with freſh parcels of hot water, till all the hepatic taſte and odour is entirely waſhed away, and now the cinnabar will be very beautiful, differing from the common ſublimed by a ſlight tint of yellow. A farther improvement in the cinnabar may now be brought about by the proceſs of waſhing over: for this purpoſe let two or three ounces be put into a glaſs jar with ſome cold water, and mix the whole accurately by ſtirring, then, after an interval of a few ſeconds to allow the heavier particles to ſubſide, pour the turbid water into a diſh, and drain it off again as ſoon as it has become clear. The cinnabar thus ſeparated will be found to be very brilliant, and approaching to carmine: the reſidue may be treated twice more ſucceſſively in the ſame manner, and two more parcels of cinnabar inferior to the firſt, but ſtill very good may be obtained, the reſidue is a brown ſulphuret of mercury of no value as a pigment. To give the cinnabar the higheſt degree of beauty it is now to be dried ſlowly, and then is to be laid in ſmall quantities at a time on a plate of glaſs or glazed earthenware, pretty ſtrongly heated; the colour in an inſtant becomes brown, and then a very dark violet grey; it is now to be thrown upon a cold plate, where it paſſes in an inſtant to a brilliant carmine red.

Concerning the nature of the chemical action that takes place in the preparation of mercury by the moiſt way, there has been much controverſy, nor is the ſubject even yet entirely free from difficulties. From the experiments however of Prouſt, Berthollet, and other chemiſts, it appears 1ſt, that the pure and recently prepared alkaline hydroſulphurets have no action on metallic mercury; but that when by expoſure to the air theſe hydroſulphurets become coloured and converted into hydroguretted, or more properly into hydroſulphuretted ſulphurets, the mercury decompoſes them by uniting with the ſulphur, and thus reducing them again to the ſtate of ſimple hydroſulphurets; the mercury is by the ſame proceſs changed into the black ſulphuret, and is ſparingly ſoluble in the ſupernatant hydroſulphuret. As ſoon however as the black ſulphuret is changed to cinnabar it ceaſes to be ſoluble in an alkaline hydroſulphuret, whence the ſupernatant liquor at the concluſion of this proceſs conſiſts merely of the alkali combined with a variable proportion of ſulphuretted hydrogen, as is manifeſt from its giving out ſulphuretted hydrogen, but no ſulphur, by the action of acids.

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[a] Nich. Journ. 4to. II. p. 1.

2. If inſtead of an alkaline hydroſulphuret, a liquid alkaline ſulphuret, holding as little as poſſible of hydroſulphuret be employed, the action of the mercury is immediate, the whole of the ſulphur combines with the metal, and the ethiops thus produced is partly taken up by the alkali, but is depoſited again as ſoon as the ethiops is converted into cinnabar, ſo that the clear and colourleſs ſupernatant fluid contains now only alkali with the caſual quantity of ſulphuretted hydrogen originally contained in it, and which appears to have been entirely inert during the whole proceſs.

3. If to a pure alkaline hydroſulphuret there be added ſome red oxyd of mercury, the liquor becomes hot, acquires a yellow colour, and if the proper quantity of metallic oxyd has been uſed, both the hydroſulphuret and metallic oxyd will be entirely decompoſed; the oxygen of the one and the hydrogen of the other by their combination will produce water, the mercury will ſaturate itſelf with ſulphur and become ethiops, and the ſupernatant liquor is a pure alkaline ſulphuret from which the acids are capable of precipitating the ſulphur, but of not ſeparating a ſingle atom of ſulphuretted hydrogen.

4. If a ſolution of common alkaline hepar or hydroſulphuretted ſulphuret, be firſt brought to the ſtate of ſimple ſulphuret by the addition of a little red oxyd of mercury, and there be afterwards added a freſh portion of oxyd, a great increaſe of temperature is obſerved, part of the ſulphur is converted into ſulphureous acid by a portion of the oxygen, while the remainder of the oxygen quits the metal and aſſumes the gaſeous ſtate, cauſing an effervescence during its diſengagement: when this has taken place the ſupernatant liquor contains the alkali of the hepar with a little ſulphureous acid, and often a ſmall quantity of red oxyd if an exceſs of this ſubſtance has been made uſe of.

The deduction from theſe experiments is, that neither oxygen nor ſulphuretted hydrogen enter into the compoſition of ethiops or cinnabar; and it is highly probable that the only difference between them conſiſts in the proportion of ſulphur.

Phoſphorus may be made to combine with mercury[b] by diſtilling together equal parts of red oxyd of mercury and phoſphorus, together with a little water: during the proceſs the red oxyd becomes black and unites to the phoſphorus, and phoſphoric acid is produced. This combination may be more eaſily effected according to Dr. Thomſon, by uſing the grey oxyd of mercury. Phoſphorus and mercury in the metallic ſtate cannot be made to combine, except the latter is in a ſtate of extreme diviſion. Phoſphuret of mercury is a ſubſtance of a moderately ſolid conſiſtence, a black colour, and may be cut with a knife; when expoſed to dry air it exhales white vapours of phoſphorus. It is decompoſed by diſtillation, the phoſphorus firſt comes over and then the mercury, each ſubſtance being found in the receiver perfectly ſeparate.

Mercury is capable of uniting with many of the other metals, and theſe combinations have obtained the name of Amalgams. They have received conſiderable attention from various chemiſts, though by no means ſo much as their chemical importance deſerves. Before we proceed to notice the particular amalgams we ſhall mention a few general obſervations that are applicable to all of them.

Firſt with regard to the preparation of amalgams. It may be remarked that the care neceſſary in their preparation depends conſiderably on the degree of affinity ſubſiſting between the mercury and the other metal. Where the affinity is very powerful, as is the caſe with gold and ſilver, the fluidity of the mercury without any other condition will effect a combination even at the common temperature. Other metals of ſtronger coheſion or weaker affinity require the aſſiſtance of heat to make them amalgamate; while thoſe metals that are infuſible, except at a temperature equal to the rapid volatilization of mercury, as copper, require peculiar precautions to bring about a combination. Amalgams may be made either ſolid or fluid, according to the proportion of mercury that enters into this compoſition; the quantity however of this laſt that is required to give the amalgam a fluid ſtate, is different for each metal.

2. All the appearances that happen during the compoſition of metals with mercury indicate a real ſolution of one in the other, owing to the chemical attraction between the bodies ſo uniting. Hence during amalgamation as is the caſe in all other inſtances of ſolution, a very obſervable change of temperature takes place. Another remarkable phenomenon is the tendency to oxydation which both metals exhibit during their combination. Thus if biſmuth,

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[b] Mem. de Peliet. ii. p. 42.

tin, or lead, are amalgamated with mercury, a quantity of black powder is formed as the proceſs advances, which is a compound oxyd of mercury and the other metal.

The ſpecific gravity of amalgams as of all other alloys, is different from the mean ſpecific gravity of their component parts.

The more decidedly cryſtalline form of amalgams is a circumſtance that remarkably diſtinguiſhes them from other alloys. All amalgams are brittle, and any of them when broken exhibits a granular or laminated texture which by the microſcope will be found to be owing to a multitude of minute cryſtals applied by their ſurfaces to each other, but not adhering with any conſiderable force. Induced by theſe appearances M. Sage ſucceeded in obtaining regular cryſtals of moſt of the amalgams by the following method. Having prepared a very fluid amalgam by adding from four to ſix times as much mercury as of the other ingredient, he put it into a retort, and by a gentle ſand-bath heat diſtilled over a fourth or even a third of the mercury, the reſidue being then allowed to cool gradually, was found regularly cryſtallized at the bottom of the veſſel.

Amalgams may be decompoſed by heat; but the laſt portions of mercury are not driven off without a much higher degree of heat than is required for the volatilization of pure mercury. Hence a large proportion of the volatile metals and a ſmaller even of thoſe which are conſidered as very fixed, unites with the mercury and is carried over by it.

As each metal has its peculiar affinity for mercury, it is obvious that an amalgam may be decompoſed by the addition of a metal that has a ſtronger attraction for mercury than that of which the amalgam is compoſed: upon this ſubject however no very accurate experiments have been as yet made, which is the more to be regretted as it would aſſiſt the inveſtigation of the intereſting and important, but difficult ſubject of metallic alloys.

GOLD and MERCURY.

The ſtrong affinity of theſe two ſubſtances may be ſeen by dropping a globule of mercury on a plate of gold: the ſphericity of the globule will almoſt immediately be loſt, and the mercury wherever it ſpreads covers the ſurface of the gold with a bright ſilvery ſtain. The amalgam of gold may be prepared by grinding together gold leaf and mercury in a mortar with a little hot water, or by digeſting together mercury and gold filings or clippings in a crucible or flaſk, till the combination is compleat. Even if a bar of gold of conſiderable thickneſs be immerſed in mercury for a few days at the common temperature, it will not only be ſuperficially corroded, but will be rendered ſo brittle as to break with a very moderate force; and its fracture will exhibit minute threads of mercury that have inſinuated themſelves through its pores and thus deſtroyed its ductility. Amalgam of gold is of a yellowiſh white colour and cryſtallizes in tetrahedral priſms, when compoſed of ſix parts of mercury to one of gold. It melts at a moderate temperature and at a higher the mercury flies off leaving the gold behind. If a very fluid amalgam conſiſting of 1 part of gold to 48 of mercury, be expoſed with acceſs of air to a moderate heat (as in the preparation of precipitate *per ſe*) not only the mercury, but even the gold will be oxydated. At a ſomewhat higher heat both oxyds are again reduced to the metallic ſtate.

SILVER and MERCURY.

Silver in the order of its affinity for mercury ſtands next to gold, and its amalgam may be prepared in preciſely the ſame way. Its colour is ſilvery white, it cryſtallizes in octohedrons: its ſpecific gravity is remarkable, being greater even than that of mercury, the heavieſt of its ingredients, hence it ſinks in this fluid when at the common temperature, as was firſt obſerved by Gellert. That moſt beautiful preparation the *Arbor Dianæ*, is a cryſtallized amalgam of ſilver, for a particular account of which we refer the reader to the article SILVER.

TIN and MERCURY.—LEAD and MERCURY.—ZINC and MERCURY.—BISMUTH and MERCURY.

Theſe amalgams are prepared by melting the ſolid metal in a crucible and adding to it as ſoon as the fuſion is compleated an equal weight of mercury previouſly made nearly boiling hot in another crucible, and then keeping the mixture at a temperature fully equal to preſerve its fluidity till the combination is compleat. All theſe amalgams are poſſeſſed of conſiderable ſolidity; their colour is intermediate between that of the metals of which they are compoſed; and their texture is granular. If equal parts of the ſolid amalgams of lead and biſmuth are triturated in a mortar, a combination ſpeedily takes place, and the reſult is a compound amalgam very nearly as fluid in the common temperature as pure mercury: advantage is taken of this property by fraudulent dealers to adulterate mercury by a mixture of theſe two cheaper metals, and when the mercury amounts to 70 or 80 per cent. it is not eaſy from the mere look to detect the cheat. If the mixture of theſe two amalgams be made in the palm of the hand a ſenſation of cold is experienced during the combination nearly equal in intenſity to that produced by the evaporation of common ſpirit of wine. If a ſtick of tin be placed in this fluid compound amalgam when the weather is cool, it will be found in the courſe of two or three days to be conſiderably corroded by the mercury, at the ſame time cubic cryſtals of amalgam of biſmuth, apparently with a very ſmall proportion of mercury, will be found adhering to the tin. A ſimilar effect will be produced if equal parts of the amalgams of tin, lead, and biſmuth are mixed together at the temperature of boiling water, and the compound be then expoſed for a few days to a very ſlight froſt; cubic cryſtals of biſmuth nearly a quarter of an inch long will be found floating on the ſurface.

Antimony and Mercury.

The affinity between theſe two metals is but feeble, and the heat neceſſary for the fuſion of antimony being equal to that at which mercury is volatilized they cannot be conveniently mixed by fuſion. They may be made to combine however by taking ſome perfectly pure regulus of antimony, reducing it to a fine powder, and then triturating it for a conſiderable time with mercury and boiling water. The properties of this amalgam have not been examined.

Copper and Mercury.

Theſe two metals for the ſame reaſon as that alledged in the former paragraph, cannot be combined by fuſion. Filings of copper and mercury may by long trituration in hot water be made to unite. But the moſt effectual method of preparing this amalgam is the following. To a hot ſolution of ſulphat of copper add a little muriatic acid and a few ſticks of zinc, and boil the mixture for about a minute; by this means the copper will be precipitated in its metallic ſtate, and in a finely divided ſpungy form: take out the pieces of zinc, pour off the liquor and edulcorate the copper thoroughly with hot water, then pour on it a ſmall quantity of dilute nitrat of mercury, by which every particle of copper will be covered in an inſtant with a coating of mercury; now add running mercury to the amount of two or three times the weight of the copper, and a very ſlight trituration will combine them ſo far that the completion of the proceſs may be effected by heating the mixture for a few minutes in a crucible. The amalgam of copper is of a reddiſh white colour, and has not as yet been examined.

Iron and Mercury.

Iron is generally conſidered as incapable of uniting with mercury. It is ſtated however in Crell's Journal[c] that Mr. Vogel has ſucceeded by the following proceſs. Take half an ounce of iron filings and one ounce of alum and rub them together to a very fine powder, add to this from an ounce to an ounce and a half of mercury, and triturate till the amalgam begins to be formed: a little water is now to be poured in, and continued agitation had recourſe to for an hour: the alum is now to be diſſolved out and the amalgam of iron will remain behind.

A compound amalgam of iron and zinc may be prepared in the following way.[d] Make an amalgam in the uſual method of equal parts of zinc and mercury: mix this with half its weight of clean iron filings, and rub the whole accurately together in a mortar; this being finiſhed, pour on ſome muriat of iron and continue the trituration as long as any effervefcence or diſengagement of hydrogen gas takes place, when this ceaſes pour off the fluid and add more muriat, repeating the proceſs till the laſt addition of muriat ceaſes to cauſe any effervefcence. The amalgam will now be conſiderably ſtiff, and upon breaking it the particles of iron will appear imperfectly combined with the mercury. Being now carefully dried, it muſt be preſſed into an earthen crucible and covered with tallow to prevent its oxydation, and a heat being applied enough to volatilize the tallow, the amalgam will remain behind and is compleated. This compound amalgam has a ſilvery white colour, an uniformly granular texture, in hardneſs is nearly equal to reguline antimony, and is not ſubject to ruſt by expoſure to the air. It is not capable of affecting the magnetic needle..

A [e]compound amalgam of iron and tin is readily and effectually prepared by melting together a few iron nails with about four times their weight of grain tin, and then digeſting this alloy for a few hours in boiling mercury till it is diſſolved. This amalgam is of a ſilvery white colour, has a conſiderable toughneſs approaching to malleability, and attracts the magnetic needle.

Brass and Mercury.

This amalgam may be expeditiouſly and compleatly prepared by triturating an amalgam of zinc with ſulphat or muriat of copper till the liquor becomes colourleſs, and then keeping the maſs in fuſion for a few minutes to compleat the combination.[f]

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[c] Ann. de Chem. p. 39.
[d] Orig. Exper.
[e] Ditto.
[f] Ditto.

The uſes of mercury and its preparations are numerous and important. Its chief conſumption is in the ſeparation of gold and ſilver from their ores: it is alſo largely employed by the gilders. It is of ineſtimable advantage to experimental philoſophy as affording a fluid the moſt uſeful of all others for thermometers and barometers, and is of great ſervice to modern chemiſtry for confining thoſe gaſſes that are abſorbed by water. The arts are indebted to mercury for the ſilvering as it is called of mirrors, the gilding of buttons and other articles, and for that beautiful pigment cinnabar. The ſalts of mercury are of important uſe in the laboratory; and medicine is indebted to this metal in almoſt all its combinations for ſome of its moſt powerful and beneficial inſtruments.

MERCURY FULMINATING (*Howard's*). This ſingular preparation was diſcovered by E. Howard, Eſq. F.R.S. in a ſeries of experiments on the action of alcohol on nitric acid.[a]

The mode of preparing it is the following. Diſſolve 100 grains of mercury in an ounce and a half (by meaſure) of common nitric acid of the ſhops, which is of the ſpecific gravity of about 1.3, aſſiſting the ſolution by heat. When cold pour the ſolution upon 2 ounces (by meaſure) of ſtrong alcohol, and apply a moderate heat till the mixture begins to efferveſce. A white fume then begins to undulate on the ſurface of the liquor, during which a white powder precipitates which is the fulminating mercury. This powder is to be immediately waſhed with cold water, and dried at a heat not much exceeding that of boiling water.

In making this powder the preciſe ſtrength of the alcohol and of the acid are not of great importance. The quantity produced varies extremely, but is on an average about 125 grs. from 100 of mercury. The colour is in general white. The temperature required for mixing the nitrous ſolution and the alcohol, ſhould be about 80° or 90°.

This powder is remarkable for the extreme force of detonation which it poſſeſſes when exploded by various methods. Theſe are either concuſſion, for when a grain or two (and no more ſhould be uſed for experiment) is laid on an anvil and ſtruck ſmartly with a hammer, it detonates with a ſtunning report, leaving the iron much indented; or heat, the proper degree of which the diſcoverer finds to be about 368° of the thermometer; or the electric ſpark; or the flint and ſteel in the method of common gunpowder; or the contact of ſtrong ſulphuric acid. It is equally inflammable in vacuo, as in air. Fulminating mercury differs from gunpowder peculiarly in this circumſtance, that the force of exploſion of the mercurial powder is almoſt immenſe and far exceeding that of gunpowder ſo as to ſplit into pieces and utterly to rend any ſubſtance by which it is confined; but on the other hand the projectile force is very feeble and far ſhort of that of gunpowder. So that when the fulminating mercury was attempted to be uſed in fire arms, a very ſmall portion of it burſt ſtrong pieces of ordnance, but where the piece ſtood the exploſion, the ball was expelled with only a trifling force.

The compoſition of this powder is ſomewhat complex, and the analyſis rather obſcure. Mr. Howard examined it chiefly in the following manner. Sulphuric acid, diluted with as much water, when digeſted on the powder with gentle heat, diſengaged a quantity of gas amounting to from 28 to 31 cubic inches from 50 grains of the powder. Of this gas the greater part was carbonic acid, but after this had been abſorbed by ammonia there remained about 5 to 7 inches of a gas reſembling in every reſpect the *nitrous etherized gas* after ſimilar expoſure to dilute ſulpuric acid. This peculiar gas is highly inflammable, and enlarges the flame of a taper like the gaſſeous nitrous oxyd, and reſembles the latter in other properties, but differs from it in being permanent over water and in refuſing to detonate with hydrogen. The reſidue of 100 grains of the fulminating mercury after treatment with ſulphuric acid was an inſoluble powder weighing 84 grains, and was found to conſiſt of *oxalat of mercury* with a few globules of mercury in the metallic ſtate. It was proved to be oxalat of mercury by digeſting it with nitrat of lime, whereby (by a double decompoſition) nitrat of mercury and oxalat of lime was produced. The ſulphuric liquor after ſeparation of the inſoluble powder was then ſaturated with carbonat of potaſh, and 3.4 grains of carbonat of mercury were collected.

From the reſult of many experiments, Mr. H. concludes that 100 grains of the fulminating powder conſiſt, nearly, of 21.28 of oxalic acid, 64.72 of mercury, and the remaining 14 parts neceſſary to compleat the 100, are to be allowed for the nitrous etherized gas and an exceſs of oxygen with which the mercury appears to be united. But it muſt be obſerved that the exact compoſition of this ſingular powder ſtill requires much elucidation. The carbonic acid which forms ſo large a portion of the gas expelled by ſulphuric acid is probably to be attributed to the decompoſing action of this acid on part of the oxalic acid, whence ariſes another ſource of difficulty in obtaining an exact analyſis.

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[a] Phil. Tranſ. for 1800.

As the original materials of which the fulminating mercury are compoſed are nitric acid, alcohol, and mercury, the oxalic acid muſt be formed during the proceſs by the action of the acid on the alcohol, (a fact which has been frequently obſerved in experiments on nitrous *ether*) and ſo completely is the acid decompoſed that no trace of it appears (as acid) in the powder when compleat.

The quantity of mercury actually obtained from 100 grains of the powder by no means equals the quantity employed in the proceſs, for 100 grains of mercury produce at leaſt 120 of fulminating powder, whence if the whole of the mercury went to the compoſition of the powder, 100 grains of this latter ought to contain 78 grains of mercury, but only about 64 are actually obtained. This deficit of 14 grains from 78, Mr. H. ſuppoſes to be volatilized in the denſe white fume which ariſes during the mutual action of the alcohol and nitric acid, and which when condenſed in bottles filled with a ſolution of muriated ammonia was found to give a mercurial precipitate with ammonia, preciſely ſimilar to that produced by ammonia and corroſive muriat of mercury.

Mr. Burkitt has the following uſeful practical remarks on the preparation of this powder.[b] Three ounces of mercury were diſſolved in 1¼ lb. of nitrous acid. The ſolution was poured into a large retort, into which had been previouſly put 1¼ lb. of alcohol warmed to 80°. In three minutes the uſual efferveſcence took place and the gas was conveyed into a large globe receiver in contact with water. In about twenty minutes the proceſs was compleat, without the aſſiſtance of artificial heat, and the fulminating powder precipitated, which when waſhed and dried weighed 3 ounces and 1 dram. The water in contact with the gas was covered with 4 ounces of nitric ether which floated on it.

It is a very remarkable and quite unaccountable circumſtance obſerved by Mr. Cruikſhank, that the mercurial powder when exploding will not fire gunpowder; for on ſpreading ſome of the former on paper, and ſhaking ſome gunpowder over it, and firing the mercurial powder, the grains of gunpowder were collected entire after the exploſion.

MERCURY *Fulminating (of Bayen.)* See MERCURY.

MERGEL. See MARL.

MEPHITIS is a general term for *foul* or *unreſpirable* air of whatever kind it be, and uſually is applied either to azotic or carbonic acid gaſſes.

MESOTYPE. See ZEOLITE.

METAL. It is worthy of remark that the definitions of chemical bodies, in proportion as that ſcience has advanced, have been drawn leſs from their ſenſible qualities and more from their chemical ones, from which if ſome advantages have been derived yet conſiderable diſadvantages have alſo hence ariſen. Thus if a metal be defined, *a combuſtible or oxydable ſubſtance capable when in the ſtate of oxyd of uniting with acids and forming with them compound ſalts,* we ſhall be in poſſeſſion of a character applicable to all metals and to no other claſs of bodies, and yet ſhall not have mentioned one of thoſe properties which doubtleſs firſt led to the diſcovery of metals, and in which their principal value as ſuch muſt always conſiſt.

The only metals known to the ancients were gold, ſilver, copper, iron, tin, lead and mercury; and all theſe with the exception of the laſt, being malleable, ductile, fuſible and capable of being poliſhed, their uſe moreover chiefly depending on theſe properties, the qualities of malleability, ductility, fuſibility and of receiving a poliſh were conſidered as eſſential to and characteriſtic of metallic ſubſtances. At length the liſt of ancient metals was augmented by the addition of three new ones, antimony, biſmuth and zinc, but theſe, though agreeing in other reſpects with the former, being more or leſs brittle, it was found expedient to ſubdivide this claſs of natural ſubſtances into the malleable or proper metals, and the brittle or ſemi-metals. Much about the ſame time aroſe the chemical diſtinction of metals unalterable by expoſure to the air at a fuſing heat, and thoſe which in the ſame circumſtances were liable to be calcined. The former of theſe were called perfect or noble metals, and the latter imperfect or baſe metals: of the baſe metals ſome were afterwards found to be acidifiable, whence aroſe another ground of diſtinction.

The number of metals at preſent known, amounts to 27, which may be tabularly arranged as follows.

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[b] Phil. Mag. vol. 17.

- METALS
  - *oxydable by heat*
    - *acidifiable*
      - *volatile*
        - Arſenic
      - *fixed*
        - Molybdena
        - Tungſten
        - Chrome
        - Columbium
    - *not acidifiable*
      - *brittle*
        - *infuſible or granular*
          - Oſmium
          - Uranium
        - *fuſible*
          - Tantalium
          - Titanium
          - Tellurium
          - Manganeſe
          - Cobalt
          - Antimony
          - Biſmuth
      - *malleable*
        - Zinc
        - Lead
        - Tin
        - Iron
        - Copper
        - Mercury
  - *not oxydable by heat*
    - *granular and brittle*
      - Iridium
      - Rhodium
    - *fuſible and malleable*
      - Palladium
      - Nickel
      - Platina
      - Silver
      - Gold

We ſhall now proceed to notice briefly the generic characters of metallic ſubſtances.

One of the moſt remarkable is the peculiar luſtre which their ſmooth or poliſhed ſurfaces exhibit, and which from its being eminently characteriſtic of theſe ſubſtances has been called the metallic luſtre: ſome other minerals indeed, as mica, Labrador felſpar, &c. poſſeſs this luſtre in a ſtriking degree, but in all theſe it is always attended by a greater or leſs variableneſs of colour which never takes place in the pure metals, although it is very ſtriking in many of their ores.

The next remarkable property of metals is their opacity, which though very conſiderable is by no means abſolute, as ſome chemiſts have inadvertently affirmed. A piece of common leaf gold if held between the eye and a luminous object, will be found to tranſmit a green light; ſilver in the ſame circumſtances affords a white light, and it is extremely probable that all the other metals if attenuated in the ſame degree would alſo be tranſparent.

In ſpecific gravity the metals exceed all other known ſubſtances; the native ſulphat of barytes, the heavieſt of earthy minerals, being leſs than 4½ times as heavy as water, whereas the ſpecific gravity of tellurium, the lighteſt of the metals is more than ſix times as great as that of water. Of ſome of the more recently diſcovered metals the ſpecific gravity has not yet been aſcertained, nor are chemiſts by any means agreed reſpecting the relative gravity of the reſt. This ariſes partly from a difference in the purity of the ſpecimens which have been the ſubjects of experiment, but principally from the variations of denſity which the ſame metal will exhibit according to the preſſure that it has been expoſed to, either during the act of ſolidifying from fuſion, or at any ſubſequent period. The following is a liſt of the metals hitherto examined in the order of their ſpecific gravities.

Platina (hammered) - - -	23.00
Gold - - - - - - - -	19.25
Ditto laminated - - - -	19.36
Tungſten - - - - - - -	17.60
Mercury (fluid) - - - -	13.56
Palladium - - - - - -	11.87
Lead - - - - - - - -	11.35
Rhodium - - - - - - -	11.00
Silver - - - - - - - -	10.47
Ditto laminated - - - -	10.51
Biſmuth - - - - - - -	9.82
Uranium - - - - - - -	9.00
Molybdena - - - - - -	8.60
Nickel - - - - - - -	8.51

Arſenic - - - - - - -	8.31
Ditto, according to Fourcroy	5.76
Copper - - - - - - -	7.78
Ditto in wire - - - - -	8.89
Cobalt - - - - - - -	7.64
Iron - - - - - - - -	7.60
Ditto hammered - - -	7.78
Tin - - - - - - - -	7.29
Zinc - - - - - - - -	7.06
Manganeſe - - - - -	6.85
Antimony - - - - -	6.71
Tellurium - - - - -	6.11

The fuſibility of metals is a property that eminently contributes to their uſefulneſs, ſince without this it would ſcarcely be poſſible to ſeparate them from the earths and other impurities with which they are naturally mixed, unleſs at an immoderate expence both of time and labour; not to mention the vaſt advantage as well as in accuracy as economy, of producing a veſſel or inſtrument by pouring the fluid material into a mould inſtead of laboriouſly carving it out from the block by the hammer and chizel or turning it in a lathe. The range of temperature at which the various metals become fluid, extends from the higheſt heat that our furnaces can produce, to a degree of cold never occurring naturally, except in Siberia and the other inclement regions of the fartheſt north. The following is the order of fuſibility as far as it has hitherto been aſcertained.

Mercury -	at — 39° Fahrenheit.
Tin - -	from 442° Fahr. to a temperature juſt below that of red heat.
Biſmuth -	
Lead - -	
Tellurium -	
Zinc - -	
Antimony -	low red heat.
Silver - -	from a bright or cherry red to a low white heat.
Copper - -	
Gold - -	
Cobalt - -	from a full white heat to the greateſt heat of a wind or blaſt furnace.
Nickel - -	
Iron - - -	
Palladium -	
Manganeſe -	
Titanium -	
Platina - -	capable of being rendered ſoft and coheſive, but ſcarcely fuſible in the greateſt furnace heat.

Some metals however appear to be abſolutely incapable of proper fuſion, on which account they can only be obtained in the ſtate of ſlightly cohering ſcales or grains, very different from the button formed by the fuſible metals. That this granular form is not occaſioned by a deficiency of heat, is manifeſt from the volatilization of theſe metals without fuſion by an increaſed temperature. Thus arſenic is converted into vapour at the heat of melting lead, tungſten at a very intenſe white heat, and perhaps molybdena, chrome and uranium at a ſomewhat higher temperature. Many of the properly fuſible metals are alſo known to be volatilizable at a heat conſiderably above their point of fuſion, and this is probably the caſe with all of them. Theſe two effects however, though depending on the progreſſive energy of the ſame cauſe, heat, by no means follow the ſame order; arſenic ranks the firſt in volatility, then comes mercury, to which ſucceed zinc and antimony. All the fuſible metals may be obtained in a cryſtalline form, by means which has been already related in the article CRYSTALLIZATION.

Another ſtriking and valuable property of metals is their extenſibility. This by the ancients was reckoned one of the eſſential characters of metallic bodies, but has ceaſed to continue ſo in conſequence of the diſcovery of a number of metals deſtitute of this quality. Its high importance however may be well judged of by obſerving that for almoſt all mechanical purpoſes the intrinſic value of metals is intimately dependent on their extenſibility. Metals are extended either by hammering or laminating, in which caſe they are ſaid to be malleable, or by wire-drawing, when they are ſaid to be ductile. The metal of greateſt malleability is gold, which may be beaten into leaves ſo thin that they will float in the air like a feather: ſilver may alſo be reduced to nearly the ſame ſtate of tenuity: after theſe may be ranked in the following order copper, tin, lead, iron and zinc; this laſt however in order to be perfectly malleable, muſt be made ſomewhat hotter than boiling water. The other malleable metals are platina, palladium, nickel and mercury, but no experiments have been made with ſufficient accuracy to aſcertain their proper place in the ſeries: it appears probable however that the three firſt ſhould be inſerted between lead and iron. With regard to mercury, its extreme fuſibility muſt ever oppoſe an inſurmountable obſtacle to the determination of its malleability. It might at firſt ſight appear to be a neceſſary conſequence that the ductility of metals ſhould follow the ſame order as their malleability, both properties being merely a mode of extenſion; but a little reflection on the proceſs of wire-drawing will evince that the ductility of a ſubſtance is compounded of its malleability and tenacity; hence iron, though by no means ſo malleable as tin or lead, greatly ſurpaſſes them in ductility. All metals, in a greater or leſs degree, while undergoing the proceſs of hammering or wire-drawing, give out heat and ſuffer a proportionable increaſe of ſpecific gravity; but at the ſame time and in the ſame proportion they become rigid and more diſpoſed to break or tear than extend evenly: their original ductility and ſoftneſs may however be reſtored by annealing, which conſiſts in heating them moderately and allowing them to cool gradually; by this the heat which was expreſſed from them is reſtored, and their ſpecific gravity is reduced to its original amount. The quantity of expreſſible caloric contained in tough bar iron is ſo great that by rapid hammering it may actually be made red hot, whereas lead by the ſame treatment has its temperature raiſed only a few degrees.

The tenacity of a metal is eſtimated by the weight required to break a wire of a given diameter when ſuſpended at one end of it while the other end is made faſt to a bar. The moſt accurate experiments on this ſubject are thoſe of Sickingen, from which it appears that

a wire of iron $\frac{1}{10}$ of an inch in diameter will bear 705. lbs. avoirdupois before it breaks,
——— copper ——————————— 387.
——— platina ——————————— 351.
——— ſilver ——————————— 239.
——— gold ——————————— 191.

The tenacity of tin is greatly inferior to that of gold, and the tenacity of lead is the leaſt of all.

On the chemical properties of metals a few words will ſuffice, as each individual metal is treated of much at length in its proper place.

Metals are ſimple ſubſtances; at leaſt if they are not abſolutely ſo, yet there is no inſtance of any one of them having been hitherto decompoſed, notwithſtanding the almoſt innumerable proceſſes to which they have been ſubjected for this very purpoſe. The metals are very generally by modern chemiſts ranked among the ſimple combuſtibles, and indeed in many reſpects a very ſtrong analogy exiſts between them. By mere heat they undergo no change except of form, becoming liquid or aſſuming a ſtate of elaſtic fluidity according to the degree of temperature: but when expoſed at the ſame time to heat and oxygen gas, they enter into active combuſtion and unite with oxygen, light and heat being evolved during the proceſs. Nor are they only capable of combining with oxygen when preſented to them in the ſtate of gas, but alſo of decompoſing many ſubſtances into which this ingredient enters by means of their ſtrong affinity for it. Hence atmoſpheric air, water, the compound acids, and ſeveral of the neutral ſalts are thus capable of being decompoſed; the metal becoming oxydized, and the other baſe with which the oxygen was at firſt united being either entirely deprived of it or reduced to a low ſtate of oxygenation according to circumſtances. The affinity for oxygen manifeſted by the different metals is extremely various in degree, ſome entering into active combuſtion when expoſed to atmoſpheric air at a heat ſomewhat greater than that required for their fuſion, as zinc and iron, while others in the ſame circumſtances are ſlowly oxydized without much appearance of combuſtion, and others again, as gold, ſilver and platina, appear wholly incapable of being oxydized by this proceſs. A ſimilar difference may be remarked in the habitudes of metals with regard to every mode of oxydation, whether through the medium of the decompoſition of water, of acids, or of the neutral ſalts. Some metals are capable of combining with oxygen in two or more proportions, as iron, lead and tin, but even in the higheſt ſtate of oxygenation they never aſſume acid characters; while on the other hand ſome metals, as arſenic, molybdena and chrome, when ſaturated with oxygen, are compleat acids, exhibiting every character of ſuch. Metallic oxyds and acids may all be brought back again to the reguline or proper metallic form by being expoſed to the action of any ſubſtance that has a ſtronger affinity with oxygen than they themſelves poſſeſs; thus charcoal, hydrogen, phoſphorus and ſulphur, though in certain circumſtances they are deoxygenized by the metals, are very capable in other circumſtances of decompoſing metallic oxyds by abſtraction of their oxygen.

Metals when in the ſtate of oxyd are capable of uniting with acids forming the metallic ſalts, with ſulphuretted hydrogen, and in ſome caſes with the alkalies; at a high heat they become more or leſs tranſparent, aſſume the vitreous texture, and are called metallic glaſſes; they are now capable of mixing with other vitreſcent mixtures, to which they communicate their own peculiar colours.

Metals in the reguline ſtate combine with each other, forming various ALLOYS, and with phoſphorus, carbon and ſulphur, forming the metallic phoſphurets, carburets, and ſulphurets.

MICA. Glimmer *Wern.* Mica, *Hauy and Broch.*

Its colour is aſh or ſmoak-grey, yellowiſh, greeniſh and blackiſh grey; it alſo occurs ſilvery white, bronze yellow, copper-red, browniſh red, tombac-brown, blackiſh brown, greeniſh black, and mountain green. It occurs moſt uſually diſſeminated, often ſuperficial, rarely in maſs, and ſtill more rarely cryſtallized. Its primitive figure is a ſhort ſtrait priſm with rhomboidal baſes, the alternate angles of which meaſure 60° and 120°. It alſo occurs in ſhort regular hexahedral priſms or tables. Sometimes the lateral edges are replaced by planes, forming an angle of about 100° with the baſe to which they adjoin, thus repreſenting a very ſhort hexahedral priſm terminated by very deeply truncated hexahedral pyramids. It alſo ſometimes preſents rectangular tables. The baſes of the cryſtals are ſmooth and ſhining: internally it is ſhining and very ſhining, with a reſinous, pearly, or metallic luſtre. Its fracture is generally ſtrait, curved, or undulatingly foliated, ſometimes, though rarely, divergingly radiated; its fragments are tabular and indeterminately angular. When in maſs it is compoſed of granular and wedge-ſhaped diſtinct concretions. When in thin plates it is tranſparent or ſemitranſparent; thoſe varieties with a metallic luſtre are only tranſlucent on the edges. It may be ſcraped eaſily by a knife, is flexible and moderately elaſtic, when in thin plates may be cut like ſoft horn, and is ſmooth but not unctuous to the touch. Sp. gr. 2.79 to 2.93.

Before the blowpipe mica fuſes with difficulty into an enamel, which, when black mica is employed, is uſually magnetic.

Mica has been analyſed by Vauquelin, and the variety called Muſcovy Talc by Bergman, with the following reſults:

	Vauq.	Berg.
Silex	50	— 40
Alumine . . .	35	— 46
Lime	1.33	— 0
Magneſia . . .	1.35	— 5
Oxyd of Iron . .	7..	— 9
	94.68	100
Loſs . .	5.32	

Mica is conſidered as belonging eſſentially to the primitive rocks, and for the moſt part aſſociated with quartz and felſpar, as in granite, gneiſs, and micaceous ſchiſtus: it is for the moſt part diſperſed through the entire ſubſtance of theſe rocks and occaſionally forms ſmall veins, in which laſt the maſſive and cryſtallized varieties are almoſt excluſively found. In the moſt ancient large grained granite plates of mica frequently occur of the length of three inches or more; and the veins of mica which occaſionally traverſe this ſpecies of rock have been known to afford plates nearly 5 feet ſquare. Mica in ſmall ſpangles is by no means unfrequent in the ſlaty ſandſtone that accompanies the independent coal-formation and the beds of alum ſlate: it is alſo met with, though more rarely, in the rocks of trap-formation.

The large plates of mica called Muſcovy Talc or Muſcovy Glaſs, are procured chiefly from Ruſſia; of late years a ſomewhat inferior kind has been dug in the province of Penſilvania in America: it is tranſparent, has a ſmoaky tinge, and is in common uſe inſtead of window-glaſs in the neighbourhood where it is procured. It was employed inſtead of glaſs in the windows of the Ruſſian ſhips of war, as not being liable to be broken by the concuſſion of the air during the diſcharge of heavy artillery, but it has the inconvenience of never being ſo tranſparent as glaſs, and of becoming dim by continued expoſure to the ſea air. Muſcovy Talc may be divided into plates of almoſt incredible tenuity, ſome of them according to Hauy being no thicker than $\frac{1}{500000}$ of an inch; this circumſtance added to its toughneſs and flexibility, render it peculiarly proper for incloſing objects to be inſpected by the ſolar microſcope. The gold and ſilver-coloured mica called vulgarly Cat's gold and ſilver, is employed with good effect in froſt-work ornaments inſtead of more coſtly materials.

MICACEOUS SCHISTUS. Glimmerſchiefer *Wern.* Schiſte micacé *Broch.*

Micaceous ſchiſtus is a ſpecies of rock belonging to the claſs of primitive ones, and is of great importance both in a geological and mineralogical point of view. Both its name and external characters are derived from the mica which it contains, and which is always the moſt ſtriking, and occaſionally the predominating ingredient. It conſiſts eſſentially of minute plates or ſpangles of mica lying all in one direction, with granular quartz interpoſed. The colour of the quartz is white or grey, that of the mica is ſilvery white, or greyiſh white with a metallic luſtre, ſometimes brown, and rarely greeniſh. The fracture of this mineral in the direction of the mica is ſlaty, though not properly laminated. When pure, it is hardly fuſible without a flux.

In ſome varieties of micaceous ſchiſtus a conſiderable quantity of felſpar is contained, when this is the caſe its texture becomes coarſer, and it is ſcarcely to be diſtinguiſhed from gneiſs; other varieties conſiſt entirely of mica and granular quartz, but this latter in ſo great a proportion to the other ingredient that its ſlaty texture is almoſt entirely obſcured.

Micaceous ſchiſtus frequently incloſes other minerals, particularly garnet, felſpar, cyanite, and tourmalin.

Mountains of micaceous ſchiſtus are by no means ſo ſimple in their ſtructure as thoſe of granite and gneiſs, ſince they frequently contain beds of primitive limeſtone, hornblende, ſlate, and rarely primitive gypſum; beds of actynolite, pyrites, galena, and other metallic ores are alſo occaſionally met with. Some of the richeſt metallic veins are alſo ſituated in this ſpecies of rock, as is the caſe with moſt of the mines of Sweden and Norway, and with a conſiderable number of thoſe in Saxony and Hungary. Micaceous ſchiſtus generally repoſes on gneiſs, and forms mountainous chains of conſiderable extent, though ſeldom of any great heighth. The moſt intereſting chains of this ſpecies of mountain in Britain are the vales of the Tay, and the Tùmmel, Strath Errick, and Glen Roy, in the Scottiſh highlands.

Micaceous ſchiſtus, when pure, is in much requeſt for the walls and hearths of furnaces on account of its great infuſibility; it is alſo ſplit into leaves for covering houſes, though for this purpoſe it is inferior to ſlate.

MICARELLE. See Pinit.

MICROCOSMIC SALT is the compound Phosphat *of Soda and Ammonia* (which ſee).

MILK. Milch. *Germ.* Lait. *Fr.*

This fluid, the next in importance of all the animal liquors to blood, has been examined very largely by different chemiſts, and its analyſis is curious and important. Scheele,[a] Fourcroy,[b] and Vauquelin, Parmentier and Deyeux,[c] and many others have given particular attention to this ſubject, and from their united labours the following general account of its properties may be given.

Milk is a white opake fluid, varying in hue from a yellowiſh to a blueiſh tint, of a ſoft ſomewhat unctuous feel, and a ſweetiſh and grateful taſte. It frequently is altered in taſte and ſmell and ſometimes too in colour, by the nature of the aliment which the animal takes. The ſpecific gravity of milk varies according to the animal that produces it, the food, and other circumſtances. The gravity of cows milk is about 1.0203 according to Briſſon, and this is the lighteſt next to human milk. Sheeps milk, which is heavy, weighs 1.0409.

The chemical compoſition of this fluid is the ſame in all animals, as far as has been examined, that is, all milks conſiſt of the ſame ſubſtances in intimate combination, but the relative proportion of theſe ſubſtances is probably not the ſame in any two animals, and is ſo remarkably different in ſome, as to be obvious to common obſervers. In a general view milk may be ſaid to be compoſed of the following ingredients.

1. Of the caſeous or curdy matter, which is ſeparable from milk by various means, and particularly by *rennet*, and which when collected and condenſed by preſſure forms cheeſe.

2. Of a true animal oil, butter, which is ſeparable from the cream chiefly by agitation.

3. Of a ſweet watery fluid, the ſerum or whey, which generally contains a good deal of the two former ingredients diſſolved, and alſo holds a quantity of ſaccharine matter, of animal jelly, of muriat of ſoda, and potaſh, and ſome phoſphats.

The further analyſis of theſe three ſubſtances will be preſently mentioned.

Milk when moderately heated ſwells and froths conſiderably, and at about 200° of heat it boils. At the ſame time there forms on the ſurface a tough dry pellicle, which when removed is ſucceeded by another, and ſo on ſucceſſively. This ſkin is the ſame as the *curd* or caſeous matter obtained by the common means, and if the proceſs is continued for a great length of time, all the curd may be ſeparated in this form, and a watery liquid alone will remain.

If milk is evaporated to dryneſs there remains a ſolid yellowiſh extract, known abroad by the name *franchipane*, and formerly uſed in medicine. If the vapour diſtilled from boiling milk be condenſed in a proper receiver, it forms a clear liquor of a faintiſh taſte, which after long ſtanding becomes muddy and putrefies.

The coagulation of milk is one of the moſt important changes which it undergoes, and is effected by a variety of methods. All the acids coagulate milk, alcohol and all vinous liquors do the ſame, and alſo ſeveral vegetables. But the ſpeedieſt and moſt perfect coagulation is effected by *rennet*, or an infuſion of the ſtomach of calves, pickled and ſalted, which is the ſubſtance uſed in making cheeſe. The gaſtric juice of all animals alſo produces the ſame effect, and hence coagulation is the firſt proceſs in the natural digeſtion of this fluid.

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[a] Eſſays. [b] Encyc. Meth. Art. Lait. [c] Journ. de Phyſique.

Coagulation is the moſt convenient method of analyzing milk, and it is thereby reſolved into two principal portions, the *coagulum* or *curd*, and the *whey*. The analyſis of each of theſe ſubſtances gives the following reſults.

Whey prepared by rennet (which is on the whole the beſt ſubſtance for coagulating milk for chemical analyſis) when filtered and clarified is a limpid yellowiſh fluid, of a ſweetiſh and rather ſaline taſte, agreeable to moſt palates. Its ſpecific gravity is ſomewhat leſs than that of the milk from which it is procured. Whey when gently evaporated to the conſiſtence of a ſyrup and allowed to cool undiſturbed, depoſits a ſingular cryſtalline ſweetiſh matter called *ſugar of milk*, which is prepared pretty largely in ſome of the Swiſs cantons, and is uſed for culinary and medicinal purpoſes. To prepare it, freſh whey from ſkimmed milk is boiled down to the thickneſs of ſyrup, and then poured into earthen pots, where it ſolidifies and dries in the ſun; this maſs which is brown and impure is refined by re-ſolution, clarification with white of egg, and another evaporation, after which it concretes into white rhomboidal cryſtals.

Sugar of milk when pure is a white cryſtalline ſubſtance, of a ſweetiſh and rather mawkiſh taſte, ſoluble in four parts of boiling water and about twelve of cold. When ſtrongly heated it turns brown, ſwells up and exhales the ſtrong pungent vapour of burnt ſugar, and finally leaves a black coal holding about $\frac{1}{30}$ of its weight of ſalt, compoſed according to Rouelle, of three parts muriat of potaſh and one part carbonat of potaſh.

Sugar of milk has been uſually thought to be the chief agent in the vinous fermentation, which milk is capable of aſſuming, but it has been ſhewn by Fourcroy and Vauquelin that this is a miſtake, ſince during the proceſs no ſugar of milk is deſtroyed, as much being found after as before fermentation. Neither is it capable of fermenting by itſelf when diſſolved in water and mixed with leaven.

Sugar of milk when boiled with nitric acid repeatedly, is converted partly into oxalic acid and partly into a peculiar acid to which the term *Saccholactic Acid*, or *Acid of Sugar of Milk*, has been given. It was firſt diſcovered by the ingenious reſearches of Scheele,[d] and has ſince been found to be identic with the mucous acid. It is prepared by abſtracting nitric acid repeatedly from ſugar of milk, during which an opake white powder ſeparates firſt, and on cooling a quantity of cryſtals alſo forms. The former is the ſaccholactic acid, the latter is oxalic acid. The ſaccholactic acid is very ſparingly ſoluble in hot water, and poſſeſſes very faint acid properties, but its acid nature cannot be doubted ſince it reddens litmus, has a ſlightly ſour taſte, effervefces with chalk, and forms neutral ſalts with alkalies. It has been ſtrongly ſuſpected to be the oxalic acid, whoſe uſual properties are maſked by an intimate union with ſome animal matter, but no ſatisfactory experiments have confirmed this opinion. Its properties will be further noticed under the article Mucous Acid.

After the evaporated whey has depoſited all its ſugar of milk, the mother liquor is a brown viſcous fluid, which on cooling concretes into a tremulous jelly. It alſo contains moſt of the ſaline parts of the milk, which may be obtained by diluting it with water and again evaporating judiciouſly and ſtopping the proceſs at intervals to allow of the ſeparation of the ſalts. The moſt abundant of theſe is muriat of potaſh, which appears in ſmall regular cubic cryſtals. Phoſphat of lime is alſo contained in ſerum and ſeparates at laſt, but it may be more immediately obtained by adding lime-water to the whey before evaporation, this earthy ſalt being thereby rendered inſoluble, the lime-water neutralizing a ſmall exceſs of acid naturally exiſting in milk which holds the phoſphat in ſolution. Any of the alkalies will produce the ſame effect. The above two ſalts, muriat of potaſh and phoſphat of lime alſo appear, on calcining the dry reſidue of evaporated whey, and lixiviating with water, the heat having deſtroyed the acid which held the phoſphat of lime ſuſpended.

The phenomena attending the coagulation of milk by acids and by alcohol will be ſoon noticed, that by rennet is underſtood at preſent.

The curd of milk prepared by rennet, to be chemically pure, ſhould be made of ſkimmed milk, otherwiſe it contains much of the butter and oily part. The conſiſtence of curd depends on a number of minute circumſtances, being ſometimes quite ſoft and gelatinous, ſometimes firm and as it were knotty. It is much condenſed and hardened by heat. A long continued preſſure is neceſſary, in order to ſeparate entirely the adhering portion of whey. Curd (or cheeſe) from ſkimmed milk, when ſlowly dried in a moderate heat, becomes hard, brittle, and tranſparent like horn, which may be ſeen in ſome of the moſt ordinary cheeſes as prepared for food. Whilſt it retains its flexibility it is extremely tough and tenacious, and when heated it draws out into long ſtrings. If the heat becomes ſcorching it melts, takes fire and burns with flame, ſmoke, and a fetid ammoniacal ſmell. When diſtilled *per ſe* it alſo yields much ammonia, a fetid oil, much ſulphuretted and carburetted hydrogen, and a denſe ſaline coal from which muriat of potaſh may be obtained by lixiviation. Curd alſo contains much of the phoſphat of lime of the milk, provided the milk has not ſtood long enough to ſour and generate an acid which would keep this earthy ſalt ſuſpended. And, when dry and horny, it will keep to an indefinite time in a dry air without change, but if ſoft and not well preſſed, the whey which it contains becomes ſour, and the acid itſelf in a few days is covered with a white mould, gives out a moſt offenſive ſmell, and ſlowly putrefies. But the ſpontaneous decompoſition of cheeſe is very ſlow.

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[d] Eſſays.

Curd is inſoluble in water, but when long kept under cold water, it is changed to a ſoft fatty matter, conſiderably different from the original ſubſtance. Cauſtic alkali diſſolves curd very readily, particularly if heated, and it may be again precipitated by acids. Some ammonia is diſengaged during the ſolution. Ammonia alſo acts on curd with equal rapidity. Quicklime, curds and water, intimately united by beating, form a ſtiff paſte of extreme tenacity, which ſoon acquires a ſtrong hardneſs and is often uſed as a very firm cement.

From all the properties of pure curd it appears to bear the ſtrongeſt analogy with the white of egg, as Scheele obſerves, and it may be conſidered as nearly pure albumen, but mixed with a certain portion of phoſphat of lime and a few other ſaline matters. Rouelle compared it to the gluten of wheat, which is alſo a juſt compariſon, ſince there is alſo ſcarcely any aſcertainable difference between pure gluten and pure albumen when each is in a condenſed coagulated ſtate. The effect of acids upon curd will be preſently noticed.

Butter, or the oily part of milk, is well known to be prepared from cream by long agitation. New milk is perfectly homogenous, but on ſtanding for ſome hours at reſt it throws up a thick yellowiſh-white cream, unctuous to the touch, and of a very bland agreeable flavour. In the proceſs of churning, the cream ſeparates viſibly into two ſubſtances, the butter which collects in a maſs, and a thick white liquid, the buttermilk as it is called, and whey, and ſtill retains a little of the butter.

Butter is much more eaſily made from ſtale than from freſh cream, probably owing to the ſpontaneous change which cream undergoes by keeping, and the evolution of an acid. Butter often varies in colour, being of every ſhade from a faint yellowiſh-white to a deep yellow, but the cauſe of this variation is not very apparent. The action of the atmoſphere has been thought by ſome to be concerned in the ſeparation of cream from milk, and of butter from cream, but nothing in the leaſt degree ſatisfactory has been brought in ſupport of this opinion, and it is certain that agitation alone in a corked bottle, will perfectly ſeparate butter from cream.

Freſh butter melts at about 98°, and when kept for ſome time melted, a ſmall quantity of ſerum and curd ſeparate from it. The butter becomes thereby more tranſparent, but has acquired a leſs pleaſant taſte. Butter when diſtilled *per ſe*, firſt gives over ſome water holding ſebacic acid, after which the greater part of the butter riſes with a pungent unpleaſant ſmell, and fixes in the receiver into a concrete empyreumatic greaſe. A further diſtillation of this greaſe gives a finer and more volatile oil than at firſt, and other products ſimilar to thoſe of the animal oils, as will be further mentioned under the article Oil. Butter when long kept becomes exceſſively fetid and rancid, but this is in a great meaſure prevented by ſalting. Alkalies diſſolve it with eaſe into a perfect ſoap.

On the whole, butter may be conſidered as moſt reſembling the animal oils, but intimately combined with a ſmall portion of the curd and whey and other parts of the milk, from which probably it can never be ſeparated without total diſorganization; and indeed as milk is a natural emulſion elaborated in the veſſels of the animal, the combination of its parts appears throughout to be ſo cloſe that it is ſcarcely in the power of art to break it intirely. Hence it is that we find the whey to retain almoſt to the laſt ſome of the curd and oil; the curd to be almoſt inſeparable from the laſt portions of the whey and butter (to which much of the varieties of cheeſe is to be attributed) and ſome of the curd and whey to remain in the compoſition of butter through every proceſs.

We proceed to deſcribe the effect of acids upon milk, and the ſpontaneous coagulation of milk by the acid which is generated in it by keeping for a certain length of time.

All acids readily curdle milk, and as appears from the experiments of Scheele, confirmed by thoſe of Meſſrs. Fourcroy and Vauquelin,[e] the coagulum thus formed conſiſts of the curd united with a portion of the acid employed, inſomuch that if no more acid be uſed than is barely neceſſary, the whey ſhews no marks of acidity. The curd obtained by mineral acids (according to Scheele) is ſoluble in an exceſs of the acid, but not that produced by vegetable acids. If milk be previouſly mixed with ten parts of water, no curd is obtained by mineral acids, hence the cauſe of coagulation of undiluted milk in this caſe is, that the curd and acid together form a compound which requires for its ſolution much more water than the milk contains.

When milk is kept in a warm place it is known to grow ſour and thick in about two days, according to the temperature. This ſourneſs daily increaſes, and is the ſtrongeſt when about a fortnight has elapſed, and it then conſiſts of a ſoft curd, acid and ſomewhat nauſeous to the taſte, and of whey highly ſour and whitiſh. A ſtrong acid is therefore generated in the proceſs which was firſt accurately examined by Scheele, who diſcovered that the acid differed from any other then known, and to which he gave the name of *Lactic Acid*. It was thus prepared by this excellent chemiſt: the ſour whey was filtered and evaporated till only one-eighth remained. Some curd was ſeparated in the proceſs, which being removed by filtration the acid liquor was ſaturated with lime-water, by which a white precipitate of phoſphat of lime fell down and was removed. To the clear liquor (conſiſting of the peculiar acid and lime and ſome mucilaginous matter) juſt enough of oxalic acid was added to engage and precipitate the lime, which left the acid of the milk free in the liquor. This was then evaporated to the conſiſtence of honey, and ſtrong alcohol added, which diſſolved only the acid, leaving behind the ſugar of milk and other ſubſtances contained in the whey. The alcoholic ſolution was then diluted with water, and the alcohol diſtilled off, which finally left the lactic acid in a liquid ſtate in the retort as pure as it can ever be obtained.

The lactic acid is deſcribed by Scheele to have the following properties: evaporated to a thick conſiſtence it gives no cryſtals, and when dried it readily deliqueſces again; when diſtilled it yields water, a weak acid like the tartareous, and afterwards empyreumatic oil, acid, and an inflammable air: ſaturated with potaſh it gives a deliqueſcent ſalt, ſoluble in alcohol, and with ſoda an uncryſtallizable ſalt, but alſo ſoluble in alcohol. With ammonia and the earths it forms deliqueſcent ſalts. It diſſolves iron and zinc, giving out inflammable air, and acts upon ſome of the other metals.

It cannot be formed directly from ſour whey by diſtillation, for on making the trial, only a ſlightly acidulous water riſes in a boiling heat, and by far the greater part of the acid remains behind in the retort. From its very cloſe reſemblance to vinegar, the diſcoverer conſiders it as an imperfect acetous acid, containing the materials of this acid, but wanting the vinous fermentation to be compleatly elaborated. In proof of this opinion he adds, that if to a kanne (lb 5½ Engliſh) of milk be added four or five ſpoonfuls of brandy, and the veſſel containing it, well corked, be expoſed to warmth with occaſional exit of the vapour generated, the whole of the whey will be changed into good vinegar.

Some later experiments have been made by Meſſrs. Fourcroy and Vauquelin, on ſoured milk, particularly with a view to determine the exact nature of Scheele's lactic acid, whereby it appears moſt probable that this acid is in fact acetous acid, but with its perfect character ſomewhat maſked by holding in ſolution a quantity of animal matter. We ſhall in a few words give the leading particulars of theſe valuable experiments, as they alſo throw ſome further light on the general analyſis of milk.

A quantity of milk was let to ſtand in a warm place for five days till it was quite ſour, after which the cream was carefully ſkimmed off and the remainder was heated to compleat the ſeparation of the curd from the whey. The curd well waſhed and preſſed dried into a flexible tranſparent horny ſubſtance, which when burnt to aſhes left a ſmall quantity of aſh (much leſs than when the curd is prepared from ſweet milk by rennet) moſt of which was phoſphat of lime.

The ſour whey was then carefully analyzed in the following manner. Lime-water was added as long as any precipitate fell down, which latter was collected and calcined, during which it gave out ammoniacal oily vapours, ſhewing the preſence of an animal matter. The calcined reſidue treated with ſulphuric acid gave ſulphat of lime, and phoſphoric acid was found in the ſupernatant liquor. By evaporation of this laſt to dryneſs and calcination, the reſidue aſſumed a red colour, and on adding water part was diſſolved and a red oxyd of iron was left. The ſolution depoſited by reſt ſome cryſtals of ſulphat of magneſia. Hence it appears that the whey contained phoſphat of lime and of magneſia along with ſome iron.

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[e] Encyc. Meth. Art. Lait.

The whey, after the precipitate with limewater had been removed, was then treated with oxalic acid and evaporated in a retort to a ſmall bulk in the manner deſcribed by Scheele. The fluid expelled by evaporation was collected and found to be ſlightly ſour and ſomewhat empyreumatic, but the liquor which remained in the retort was reddiſh-brown, and very ſour, and contained by far the greater part of the lactic acid. To this liquor which was as thick as ſyrup, a large quantity of ſtrong alcohol was added, which cauſed the ſeparation of a brown thick viſcous matter, not the leaſt acid, ſoluble in water, giving a precipitate with galls, and affording carbonat of ammonia by diſtillation. By ſtanding it depoſited ſome ſugar of milk. It therefore conſiſted of ſugar of milk apparently unaltered by the ſouring of the milk, and of a peculiar animal matter. The alcoholic ſolution was highly acid and of a dark red, and by the frequent boiling it had acquired a dark colour and empyreumatic ſmell. The alcohol being diſtilled off and water added, the liquor was repeatedly treated with ſulphuric acid and diſtilled, whereby, on the one hand, there was a conſtant ſeparation of a bituminous matter, and on the other a portion of perfect acetous acid was conſtantly obtained by diſtillation. By this ingenious method the whole was reſolved into acetous acid and into a peculiar bituminous matter diſſolved therein, and to which the acid owes thoſe properties by which it differs from common acetous acid.

From theſe and other reſearches by the ſame chemiſts, it appears therefore that there is no ſuch diſtinct acid as the *lactic* of Scheele, but that it is acetous acid holding in ſolution a quantity of animal matter, to which it owes the property of giving a brown precipitate with galls, a yellowiſh-grey with nitrat of mercury, and a brown with acetite of lead; and from the ſame cauſe alſo it gradually darkens in colour and depoſits a brown matter by evaporation. The above chemiſts alſo obſerve that an acid preciſely ſimilar to the lactic is produced by diſſolving gluten in vinegar, by fermenting together a mixture of ſugar, water and gluten, and it alſo is the ſame as the *ſours* procured in ſtarch-making by the fermentation of wheat flour and water.

The lactic acid diluted with water, and long kept in a warm place, gradually loſes the whole of its acidity, depoſits a brown matter, acquires a fetid ſmell, and on adding lime gives out ammoniacal vapours. The ſame effects are alſo produced by a ſolution of gluten in vinegar.

The nature of this animal matter which by uniting with acetous acid forms the lactic acid of Scheele, is not preciſely aſcertained. It is probably the chief cauſe of that ſpontaneous change by which milk turns ſour, and largely contributes to form the acetous acid which is then generated, but it is not totally decompoſed by the acid fermentation, ſince the acetous acid when formed diſſolves a portion of it for a time, and thus protects it from further change. This matter appears alſo to differ from the curd, ſince on the one hand, when depoſited from the lactic acid by evaporation, it ſhews no reſemblance to curd; and on the other hand a ſolution of curd in vinegar will not be diſcoloured by evaporation, nor can it be brought to depoſit any ſubſtance ſimilar to the other. It is moſt probable therefore that *gluten* muſt be added to the conſtituent parts of milk.

Milk is ſuſceptible of the vinous fermentation ſo as to be made to yield an ardent ſpirit by ſubſequent diſtillation, but it is not very eaſy to ferment milk, and it always turns ſour at the ſame time. The Tartars and other Aſiatic nations have been from time immemorial in the habit of preparing an intoxicating liquor from mare's milk. This is called *koumiſs*, and the proceſs is thus given by Dr. Grieve.[c] Take any quantity of mare's milk, dilute it with a ſixth of water, pour it into a wooden veſſel, and add as a ferment about one-eighth of very ſour milk, or better, of old koumiſs, cover the veſſel with a thick cloth and keep it in a moderate temperature. After ſtanding twenty-four hours, a thick coagulum riſes to the top, which muſt be well mixed by beating. After repoſing for another day, it is again ſtirred till it becomes quite homogeneous, and in this ſtate it forms the koumiſs, which has an agreeable ſweetiſh aceſcent taſte.

Milk in the ſtate of koumiſs does not eaſily change by keeping. By diſtillation it yields a conſiderable quantity of alcohol, as much (according to Pallas) as one-third of its bulk. The entire milk appears eſſential to the production of ardent ſpirit, as well as frequent agitation to mix the conſtituent parts which the acid has cauſed to ſeparate.

The ſugar of milk (which is never abſent) will naturally be looked to as the ſource of the alcohol and the cauſe of the vinous fermentation. But Meſſrs. Fourcroy and Vauquelin deny this to be the caſe, firſt, becauſe pure ſugar of milk mixed with water and leaven, and expoſed to moderate heat will not ferment as common ſugar does, nor yield any alcohol: and ſecondly, becauſe nearly as much ſugar of milk is found in whey thoroughly ſoured by keeping, as in freſh milk. But as the above chemiſts were not able to procure any alcohol from milk ſoured in the common way, it is obvious that it cannot be at all inferred from thence that the ſugar of milk is not decompoſed in the proceſs that *does* form alcohol; but only that this ſubſtance does not appear active in the formation of the lactic (that is, the acetous) acid. Neither does it at all follow that ſugar of milk is not decompoſed in entire milk, becauſe when previouſly ſeparated from milk it cannot then be made readily to ferment. It is probable on the other hand that both the acetous and the vinous fermentations are going on at the ſame time in milk whilſt converting into koumiſs, and that the materials for theſe two proceſſes are not the ſame as in common vinous fermentation (the acetous being there chiefly a continuation of the vinous proceſs), but are, partly at leaſt, diſtinct, the gluten contributing chiefly to the acetous, and the ſugar of milk to the vinous.

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[c] Memoirs R. Soc. of Edinb. for 1788

Though the milk of different animals is found to be eſſentially the ſame in the number and chemical nature of the ſeveral ingredients (as far as has been examined), yet a very conſiderable difference is found in the proportion of theſe ſubſtances and in ſome of their ſenſible properties. The experiments of Parmentier are particularly curious on this ſubject. The kinds of milk that he examined were, firſt, cow's milk as a ſtandard, to which were compared the following, viz. woman's, aſſes', goat's, ewe's and mare's milk.

Woman's milk is ſweeter than cow's, and thinner, but it is of all others, that which varies moſt according to the ſtate of body, conſtitution, age, &c. of the perſon whence it is drawn. The cream is on the whole more copious than of common cow's milk, but it differs peculiarly in this, that neither agitation nor any other known means will entirely ſeparate the butter; the utmoſt effect of theſe means being only to give the whole cream ſomewhat of an unctuous conſiſtence, without effecting any ſeparation into butter, curd, and whey.

Human milk alſo depoſits part of its curd by mere reſt, which is found ſticking to the ſides of the veſſel which holds it. Though ſweeter to the taſte than cow's milk it does not contain ſenſibly more ſugar.

Aſſes' milk more reſembles the human than any other. The cream is in ſmall quantity, by agitation it gives a butter which is ſoft, white, and nearly taſteleſs. It ſoon becomes very rancid owing probably to its retaining a portion of the acid. By ſtanding, it depoſits much of the curd even before it becomes ſour.

Goat's milk is very thick, yellowiſh, and pleaſantly flavoured. It is ſomewhat denſer than cow's milk. The cream is remarkably thick and unctuous, and will keep a long time without growing ſour or ſenſibly changing. By agitation it gives a very firm, ſolid, and white butter, to appearance very free from all admixture. This milk alſo abounds in curd, ſo that when heated, a much thicker pellicle riſes, and when coagulated by any of the uſual methods the curd is ſo abundant that the whey is with difficulty ſeparable. It is alſo of a very gelatinous denſe conſiſtence. The ſugar of milk is ſmall in quantity, but ſeparates with eaſe.

Sheep's milk reſembles cow's very cloſely in taſte and appearance. It yields abundance of cream, which by churning affords much butter, but which always remains very ſoft. The quantity of curd is remarkably large, and it has a very fat and unctuous appearance, and a taſte which is peculiar to it, and is always very diſtinguiſhable in ewe-milk cheeſe.

Mare's milk is thin and inſipid, and does not coagulate with vinegar. It is remarkable for the ſmall quantity of cream which it gives and the extreme difficulty of ſeparating the butter from it by agitation. The whey contains ſulphat of lime, which has not been found in any other milk.

The above-mentioned ſpecies of milk all rereſemble each other eſſentially in the number and general chemical nature of the ingredients, but great diverſity appears in their reſpective proportion, and apparently in the mode of mixture. Thus with regard to the cream, cow's and ſheep's milk yield it eaſily by repoſe, its conſiſtence is greater than in the others, and the butter ſeparates more perfectly. There is an equal difference in the conſiſtence of the curd, that from cow's and ſheep's milk being denſe, and readily ſeparating by the uſual coagulating ſubſtances, but the curd from aſs's and mare's milk always remains thin, and almoſt of a creamy conſiſtence. The only general agreement which the authors of theſe experiments have been able to make on this ſubject, is that where the curd is tough and gelatinous, the butter is readily ſeparable from the cream, and all the conſtituent parts of the milk are more eaſily obtained by chemical means.

MINERALIZER is any ſubſtance found in natural combination with a metal. Thus lead is ſaid to be *mineralized* by ſulphur, when combined with it in the native ſulphuret or galena.

MINIUM. See Lead, *(Oxyds of)*.

MISPICKEL. See Arsenic, *(Ores of)*.

MOONSTONE or ADULARIA. See Felspar.

MOORSTONE. See Granite.

MORDANT. See Dying, *(Art of)*.

MORTAR. See Cements calcareous.

MORTAR (Chemical inſtrument). See the Appendix.

MOSAIC GOLD. See Tin.

MOTHER OF PEARL. See Shell.

MOTHER-WATER is the uncryſtallizable reſidue of a compound ſaline ſolution. For further particulars ſee the article Crystallization.

MOLYBDENA. *Molybdan*, Germ. *Molybdène*, Fr.

Molybdena is a metal of a greyiſh white colour, in the form of brittle infuſible grains. It is convertible to a yellowiſh white oxyd by expoſure to the air at a red heat, or by the action of nitric acid.

§ 1. *Ores of Molybdena.*

Sp. 1. Molybdena, or Sulphuret of Molybdena. *Waſſerbley*, Wern. *Molybdène ſulfuré*, Broch.

Its colour is nearly that of freſh cut metallic lead. It occurs maſſive, diſſeminated, and rarely cryſtallized. Its primitive figure is a ſtrait priſm with rhomboidal baſes, the alternate angles of which meaſure 60° and 120°. It alſo occurs in ſhort regular hexahedral priſms, the baſes of which are ſometimes terminated by ſhort hexahedral pyramids: ſometimes alſo the intervening priſm is wanting, the pyramids at the ſame time being deeply truncated. The cryſtals are ſmall or middle-ſized, and are always implanted. Internally it is more or leſs ſhining with a metallic luſtre; its fracture is curved and ſometimes radiating lamellar. Its fragments are indeterminate and blunt edged, or in irregular laminæ. It occurs in granular diſtinct concretions. It is opake, ſtains the fingers, leaves ſhining traces when drawn over paper; is very ſoft and eaſily diviſible in the direction of its laminæ; is ſectile, eaſily frangible, flexible but not elaſtic, and is unctuous to the touch. Sp. gr. 4.56 to 4.73.

It is infuſible before the blowpipe but exhales a ſulphureous odour: at a very high heat it melts, gives out white fumes and burns with a blue flame; by a long continuance of the heat it is converted into a maſs of yellow and delicate needleform cryſtals.

Its conſtituent parts are probably ſulphur and metallic molybdena, but the proportions have not yet been aſcertained with much accuracy. According to Pelletier it conſiſts of

Molybdic acid	45
Sulphur	55
	100

Some of the early experiments of Klaproth induced him to ſtate its ingredients at

Molybdena	60
Sulphur	40
	100

Laſtly, Lampadius has analyzed this mineral, and finds it to be compoſed of

Molybdena	76
Sulphur	23
Iron	1
	100

Molybdena occurs diſſeminated or in veins, in primitive mountains accompanied by tinſtone, wolfram, quartz, mica, and rarely with native arſenic, heavy ſpar, fluor ſpar, and topaz. It is found at Hitterdahl and Arendahl in Norway; Baſtnaes in Sweden; Altenberg and Zinwald in Saxony; Mont Blanc in Switzerland.

Sp. 2. Molybdat of Lead. Yellow Lead-ſpar. *Gelbes Bleyerz*, Wern. *Plomb jaune*, Broch. *Plomb Molybdaté*, Hauy.

The uſual colour of this mineral is wax yellow, which paſſes either to lemon or orange-yellow or ſometimes to a dirty honey-yellow. It occurs for the moſt part cryſtallized, very rarely maſſive. Its primitive figure is a rectangular octohedron with iſoſceles triangular faces: the incidence of the faces of one pyramid on the correſponding ones of the other is 76° 40′. The other varieties of form that it exhibits are,

1. The primitive octohedron with either all the ſolid angles or only the two vertical ones replaced by quadrilateral priſms.

2. The ſame as the preceding, with the lateral edges of the pyramids replaced by narrow triangular faces, and therefore the four ſecondary faces round the common baſe of the pyramids are not quadrilateral but hexagonal planes.

3. A rectangular parallelepiped ſometimes ſo thin as to be tabular, ſometimes approaching to the cube.

4. The cuboidal preceding variety with its terminal edges replaced by rather narrow quadrilateral planes.

5. An eight-ſided table.

6. A twelve-ſided table.

The tabular varieties are for the moſt part broad and thin and interſect each other in various directions, thus giving the whole maſs a cellular appearance. Externally it is ſmooth and ſhining; internally it is gliſtening and reſinous. Its fracture is ſmall grained uneven, paſſing into imperfectly lamellar and ſmall conchoidal. Its fragments are indeterminately angular, moderately ſharp-edged. It is tranſlucent, ſoft, rather brittle, and eaſily frangible. Sp. gr. 5.09.

Before the blowpipe it decrepitates and then fuſes into a dark grey maſs in which globules of reduced lead are perceptible; with a ſmall proportion of borax it forms a browniſh yellow globule, but if a larger quantity of borax is employed the reſult is a blue or greeniſh blue glaſs.

It has been analyſed by Klaproth, Hatchett, and Macquart, with the following reſults.

	Klapr.	Hatch.	Macq.
Molybdic acid -	34.25	38.	28.
Oxyd of lead -	64.42	58.4	63.5
Oxyd of iron -	0	2.08	0
Carbonat of lime	0	0	4.5
Silex - - -	0	0.28	4.
	98.67	98.76	100.0

This mineral was firſt met with at Villach in Carinthia, in compact lime-ſtone accompanied by calcareous ſpar, molybdena, galena and other lead ores, calamine, blende and fluor ſpar. It has ſince been found at Freudenſtein in Saxony, Annaberg in Auſtria, and Reczbanya in Hungary.

§ 2. *Aſſay and Analyſis.*

The moſt uſual method of decompoſing the ſulphuret of molybdena is by detonation with nitre; but by this means the molybdic acid becomes ſo intimately combined with potaſh as to render it extremely difficult by ſubſequent operations to obtain it pure. The beſt mode of proceeding therefore appears to be the following.

a. To one part of finely pulverized molybdena add four or five parts of moderately diluted nitric acid, and diſtil the mixture nearly to dryneſs; then return the contents of the receiver into the retort, add ſome more nitric acid and proceed a ſecond time to diſtillation; repeat this for three or four times till the inſoluble matter in the retort is as white as chalk. Now pour off the ſupernatant fluid and waſh the white matter repeatedly in warm water, adding the waſhings to the other fluid.

b. Evaporate the reſidual fluid to a moderate degree of concentration, and then pour in ammonia; the firſt portions will occaſion a precipitation, but by adding more ammonia and aſſiſting the proceſs by a gentle warmth, the whole precipitate will be re-diſſolved; then drop in ſtrong nitric acid to compleat ſaturation of the alkali, and a white precipitate will fall down, which is to be ſeparated by the filter and waſhed in warm water.

c. The reſidual fluid with the waſhings being mixed together now contains ammonia combined with nitric and ſulphuric acids, the latter of which ariſes from the oxygenation of the ſulphur in the ore. Nitrat of barytes being dropped in, a precipitation of ſulphated barytes takes place, from the amount of which the quantity of ſulphur in the ore is readily inferred.

d. The white matter obtained in proceſſes *a* and *b*, which is molybdic acid with a little oxyd of iron, muſt now be diſſolved in ſtrong ſulphuric acid, and the ſolution ſubſequently diluted with 16 times its weight of water; ammonia being now cautiouſly added to perfect ſaturation the iron will gradually fall down in the ſtate of yellow oxyd.

e. The clear liquor of the preceding proceſs being evaporated to dryneſs, the ſalt thus procured is to be ſtrongly heated in a glaſs veſſel till all the ſulphat of ammonia is expelled; what remains behind is a black bliſtered maſs, which by abſtraction with nitric acid is converted into a yellow powder, which is pure molybdic acid.

The only material objection to this method of analyſis is that the molybdena exiſts in its metallic ſtate in the ore, but is obtained in the analyſis in the ſtate of acid; and as the amount of oxygen in molybdic acid has not yet been aſcertained, this analyſis is at beſt only an approximation to a true knowledge of the ingredients of this ore, ſo long as we remain ignorant of the compoſition of molybdic acid.

The molybdat of lead has been analyſed ſatiſfactorily by Mr. Hatchett[a] in the following manner.

a. The ore, previouſly reduced to fine powder, was digeſted three ſeveral times at a ſtrong heat with ſulphuric acid, which diſſolved out the iron and molybdic acid, leaving the ſilex and lead (in the ſtate of ſulphat) behind.

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[a] Phil. Tranſ. for 1796 p. 320.

b. The fluid was ſubjected to the ſame proceſs as that deſcribed in paragraphs *d* and *e* of the preceding analyſis, by which the oxyd of iron and molybdic acid were ſeparated from each other and obtained in a ſtate of purity.

c. The white reſidue of proceſs *a* was boiled with carbonat of ſoda, and being afterwards well edulcorated was digeſted in very dilute nitric acid; the carbonat of lead was diſſolved with effervescence, leaving behind the ſilex in the form of a white powder.

d. The nitrat of lead was decompoſed by ſulphuric acid, and after the ſulphat of lead had been thus ſeparated, the reſidual fluid, after ſaturation with ammonia, depoſited a minute portion of oxyd of iron.

§. 3. *Reduction of Ores.—Phyſical properties of Reguline Molybdena.*

As molybdena is a metal that has not hitherto been applied to any uſe, ſo there has been no attempt in the great way to reduce its ores. The compleat decompoſition of the acid or oxyd of this metal, has however been undertaken by various chemiſts, and for the moſt part with but little ſucceſs. The chief cauſe of failure ſeems to have been that the ſubſtance operated on, inſtead of being the pure metallic acid, has alſo contained a portion of fixed alkali, which by its affinity for the acid moſt powerfully oppoſes its deoxydation. The method that as yet has been attended with the moſt ſatisfactory reſults is that publiſhed by Hielm. The acid being made into a paſte with linſeed oil, is to be expoſed to a ſtrong heat in a covered crucible; being then withdrawn from the fire, the black maſs is to be pulverized and again mixed with oil, and torrefied as before; by repeating this two or three times the molybdena is compleatly reduced, and aſſumes its proper metallic luſtre. It appears highly probable that the method which has been ſucceſsfully practiſed in the reduction of tunſtic acid, would be equally efficacious with the molybdic acid. It is the following. Let the pure molybdic acid be combined with as much ammonia as poſſible, and then expoſed to an intenſe heat in a crucible lined with charcoal: the ammonia would be decompoſed, and its hydrogenous baſe together with the charcoal, would probably carry off the whole of the oxygen from the metal.

Molybdena in the only ſtate in which it has hitherto been procured, is a very looſely adhering aggregate of minute grains of a yellowiſh white colour and metallic luſtre. When recently broken it exhibits a greyiſh white colour. It is hard, very brittle, and difficultly fuſible. Sp. gr. 7.5.

§. 4. *Chemical Properties.*

Moſt of the chemical properties of molybdena have been aſcertained by experiments on the native ſulphuret; theſe we ſhall firſt mention, and then notice thoſe of which the pure regulus has been the ſubject.

If the native *Sulphuret of Molybdena* is expoſed to the continued action of a low red heat with acceſs of air, the ſulphur is burnt off, and the metal is changed to a greyiſh white oxyd, of which a part is volatilized in the form of a white vapour. If the ſame experiment is performed in a wide earthenware tube paſſed through a furnace, and heated conſiderably higher than in the former caſe, the ſulphur is burnt off, and the metal in proportion as it is oxydated aſſumes the ſtate of vapour, which condenſes in the cooler parts of the tube into ſlender needleform cryſtals of a brilliant ſilvery white colour, exceedingly ſimilar in external appearance to the argentine flowers of antimony. Theſe cryſtals have a ſour metallic taſte and are molybdic acid.

Nitric acid by repeated digeſtion on ſulphuret of molybdena is itſelf decompoſed, and converts both the ſulphur and metal into acids; the latter aſſumes the form of very minute white cryſtals: by expoſing the maſs to a heat below redneſs in an earthen crucible, the laſt portions of nitric acid and nearly the whole of the ſulphuric are driven off, and by ſubſequent waſhing in water, the remainder of the ſulphuric acid is got rid of, ſo that the molybdic acid remains pure. Oxymuriatic acid has a ſimilar effect to that of the nitric, but no other acid except the arſénic exerts any action on molybdena. When this latter acid in a ſolid ſtate is ſtrongly heated in contact with molybdena, a quantity of ſulphureous acid is produced, the arſénic acid is converted into white oxyd and orpiment, a part alſo being often reduced to the metallic ſtate; what remains in the retort is a black ſhining maſs apparently conſiſting of reguline molybdena: hence it may be inferred that the action of the arſénic acid is confined merely to the ſulphureous part of the ore.[b]

Cauſtic fixed alkali unites by fuſion with molybdena into an uniform maſs of a greeniſh colour, extremely deliqueſcent and totally ſoluble in water; the ſolution exhales an hepatic odour, and on the addition of muriatic acid a copious black precipitate falls down without any ſulphuretted hydrogen being diſengaged. This black matter is conſidered by chemiſts as regenerated ſulphuret of molybdena, but from the circumſtances of the experiment appears to be a hydroguretted ſulphuret.

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[b] Pelletier Mem. i 197.

If nitre and molybdena in the proportion of two parts of the former to one of the latter be detonated together, there will be produced ſulphat of potaſh and molybdat of potaſh with exceſs of baſe, which is often miſtaken for pure molybdic acid.

The facts hitherto obſerved concerning *reguline molybdena* are but few in number and exactly analogous to thoſe that have been juſt now mentioned relating to the ſulphuret. It is oxydable by continued expoſure to air at a red heat; it decompoſes nitric and oxymuriatic acids, and is itſelf at the ſame time oxydated and acidified. When mixed with cauſtic fixed alkali and fuſed, an inflammable gas is given out, the metal is acidified and combines with the alkali. When mixed with ſulphur and expoſed to a low red heat in a retort, part of the ſulphur is volatilized and the reſidue combines with the metal into a ſubſtance exactly reſembling the native ſulphuret. It is alſo capable of uniting with phoſphorus. It forms friable alloys with iron, copper, and ſilver, the properties of which have not yet been examined.

Molybdic acid, when prepared according to the method deſcribed in §. 2, is a lemon-yellow powder of the ſp. gr. of 3.4: to the taſte it is acid and metallic. When heated in a cloſe veſſel it melts, and on cooling concretes into a ſtriated yellow maſs; in an open veſſel it is volatilized in the form of a white vapour, which as it depoſits on cool ſurfaces cryſtallizes in ſilvery needles. With borax it forms a browniſh-yellow glaſs, and with microcoſmic ſalt a glaſs, which in proportion to the acid employed varies from greeniſh to ſky blue.

It is ſoluble in about 1000 times its weight of diſtilled water; the ſolution is of a pale yellow colour, with ſcarcely any perceptible flavour; but it reddens litmus paper. Nitrat of lead is decompoſed by it, and a yellow inſoluble precipitate falls down which is molybdat of lead.

Nitrat of barytes is rendered ſlightly turbid by it; but nitrat of lime undergoes no change. Pruſſiat of potaſh produces no viſible effect, but if a few drops of any of the mineral acids are added, a copious brown precipitate of pruſſiated molybdena immediately falls down. With muriat of tin it immediately aſſumes a beautiful deep blue tinge. The ſolution receives a ſimilar but fainter tinge by being boiled with filings of any of the eaſily oxydable metals.[c]

Concentrated ſulphuric acid diſſolves at a boiling heat a conſiderable quantity of molybdic acid: the ſolution while hot is colourleſs, but as it cools acquires a fine blue colour and becomes thick. From this compound, when diluted with water, pruſſiat of potaſh throws down a reddiſh-brown precipitate. Muriat of tin produces no effect upon it. When diſtilled to dryneſs, the ſulphuric acid paſſes over and the molybdic acid remains pure. If to this ſulphuric ſolution cauſtic ſoda be added to ſaturation, the blue colour is rendered more intenſe and the molybdic acid ſeems to unite with the alkali in two different proportions; the neutral molybdat of ſoda remains in ſolution, and a white precipitate falls down, conſiſting apparently of ſoda with exceſs of molybdic acid. The ſolution is not decompoſable by pruſſiated potaſh, but is changed to a deep blue by muriat of tin. If however the ſolution be ſlightly acidulated, muriat of tin produces no change, but pruſſiat of potaſh occaſions a copious brown precipitate.

Molybdic acid when boiled with ſtrong muriatic acid is diſſolved in conſiderable proportion forming a yellowiſh-green fluid. In its habitudes with muriat of tin and pruſſiat of potaſh, both before and after ſaturation with alkali, it exactly reſembles the ſulphuric ſolution already deſcribed. When diſtilled to dryneſs, the muriatic acid paſſes over oxygenated, and the reſidue in the retort is of a greyiſh blue colour: ſome white and bluiſh flowers commonly riſe at the ſame time; they are conſiderably deliqueſcent and conſiſt of molybdic oxyd with muriatic acid.

Nitric acid has no effect on molybdic acid.

If a ſolution of carbonat of potaſh is boiled with molybdic acid, carbonic acid is diſengaged and the molybdic acid is diſſolved; in proportion however as this goes on, a white flocculent matter falls down. The liquor contains alkaline molybdat of potaſh, which is not decompoſed by pruſſiat of potaſh or changed to a blue colour by muriat of tin, except the exceſs of alkali is ſomewhat more than neutralized by the addition of ſome of the mineral acids. The white flocculent precipitate is probably acidulous molybdat of potaſh, which by digeſtion in nitric acid is reconverted into the yellow acid in conſequence of the loſs of the greateſt part, if not the whole, of its alkali.

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[c] Scheele's Eſſ. p. 233.

If carbonat of ſoda and molybdic acid are boiled together, a diſengagement of carbonic acid takes place, and, in proportion as the molybdic acid is diſſolved, a white flocculent precipitate is depoſited. The action of muriat of tin and pruſſiat of potaſh upon the clear liquor is preciſely the ſame in this caſe as in the preceding. By gentle evaporation the alkaline molybdat of ſoda may be made to cryſtallize in four-ſided tables.

Molybdic acid is taken up in greater quantity by carbonat of ammonia than by the fixed alkalies, and ſcarcely any precipitate falls during the ſolution. It is affected by pruſſiat of potaſh and muriat of tin, in the ſame manner as the preceding ſalts. By diſtillation to dryneſs the ammonia is decompoſed, and the molybdic acid is in conſequence ſo far deoxygenated as to be converted into a grey oxyd.

Molybdic acid appears to have a ſtrong affinity for that portion of alkali, whether potaſh or ſoda, which is requiſite for the conſtitution of the acidulous molybdat: hence it is that not only nitre but even ſulphat of potaſh is in part decompoſed by diſtillation at a full red heat with molybdic acid, a little nitrous acid in one caſe and ſulphuric acid in the other paſſing over into the receiver. If muriat of ſoda is treated in the ſame manner, oxymuriatic acid is given out and a portion of the molybdic acid is converted to the blue oxyd. But if inſtead of the pure acid the acidulous molybdat (produced from the detonation of nitre with the ſulphuret of molybdena) be employed, no decompoſition of the above neutral ſalts will take place.

Molybdic acid is decompoſable even in the moiſt way by hydrogen. For this purpoſe let a vial be filled with a ſolution of the acid in water and throw up hydrogen gas, till nearly half of the liquor is diſplaced, then cork the vial and ſhake it well; in a ſhort time the dilute yellow colour of the ſolution will change to blue, thus indicating a deoxygenation of the acid.

Sulphur, charcoal, and other combuſtible ſubſtances alſo decompoſe the molybdic acid; when the former is made uſe of, part of the ſulphur is converted into ſulphureous acid, and the remainder combines with the reduced molybdena into a black matter perfectly analogous to the native ſulphuret.

The different proportions of oxygen with which molybdena is capable of uniting have not hitherto been aſcertained. According to Mr. Hatchett this metal has four diſtinct ſtates of oxygenation: when at the higheſt it is of a yellow colour and is the pure molybdic acid; the next ſtep of the deſcending ſeries is the green oxyd or molybdenous acid produced by diſſolving the yellow acid in muriatic acid: to this ſucceeds the blue oxyd produced by the action of muriat of tin on either of the two former; and laſt of all is the black oxyd formed by heating molybdic acid with charcoal, yet not ſo as entirely to bring it to the metallic ſtate.

Neither the metal nor any of its preparations are made any uſe of.

MOUNTAIN BLUE. See Copper. p, 321.

MOUNTAIN GREEN. See Copper. p. 322.

MOUNTAIN CORK. See Asbest.

MUCILAGE. *Der Schleime.* Germ.

Vegetable mucilage is contained in every plant that has been hitherto analyzed, in ſome parts more abundantly than in others, and the quantity alſo varies conſiderably according to the age and other circumſtances of the vegetable. It appears to be one of the elementary vegetable conſtituents, and probably by its decompoſition in the organs of the plant it is converted into other ſubſtances, ſince it often is extremely abundant in the earlier age of the plant, and leſſens as other principles are elaborated.

The eſſential chemical properties which characterize mucilage, are the following: it is inſipid, highly ſoluble in water, giving it a thick clammy appearance and feel, inſoluble in alcohol, not coagulated by a boiling heat, not cryſtallizable, and after the watery ſolution has been evaporated to dryneſs it is again ſoluble in water without having undergone any material change.

Theſe are the diſtinguiſhing properties of mucilage in its preſent ſtate, to which it may be added that when pure and diſſolved in water, it does not readily undergo any ſpontaneous change. After a while indeed it becomes mouldy and ſomewhat ſour, but it is very ſlowly altered by this proceſs. When heated to ignition it ſwells and ſoftens, becomes yellow, brown, and black, and exhales a denſe vapour which has a pungent acid ſmell, and burns with much flame, and a ſoft ſpongy coal is left.

Mucilage is ſometimes found nearly pure, exſuding from the bark and twigs of many vegetables, by natural and artificial clefts, and hardening in the ſun into brittle nearly tranſparent roundiſh lumps. In this ſtate it may be called *Gum Mucilage.*

The pureſt of the gum-mucilages is Gum-Arabic or Senegal, which forms a very valuable article of commerce to the countries that yield it. An inferior ſort of gum for the purpoſes of manufacture, but cloſely reſembling Gum-Arabic in every property, is that which exſudes from cracks in plumb, peach, pear, and other fruit trees, and has generally the colour of amber. Beſides theſe ſources of gum-mucilage there are many vegetables whoſe native juices ſo much abound with mucilage that a conſiderably pure and ſolid gum may be obtained by ſimple decoction of the plant and evaporation to dryneſs. Several of the lichens, the leaves of the comfrey and mullen, the root of the harebell, and the whole plant of the marſh-mallow, afford a good mucilage in this method.

We ſhall firſt give a ſhort account of the gathering of the Gum-Senegal,[a] before we proceed to the chemical properties of mucilage. The Gum-Arabic is obtained in a ſimilar manner, and Cairo and Alexandria were the principal marts for this gum, till the Dutch introduced the gum from Senegal into Europe, about the beginning of the ſeventeenth century, and which now ſupplies the greater part of the vaſt conſumption of this article.

The tree which yields this gum is a ſpecies of mimoſa, which grow abundantly on the ſands along the whole of the Barbary coaſt, and particularly about the river Senegal. There are ſeveral ſpecies, ſome of which yield a red aſtringent juice, which when inſpiſſated forms the *Catechu*, but others afford only a pure nearly colourleſs inſipid gum, which is the great article of commerce. Theſe trees are from 18 to 20 feet high, with thorny branches. The gum makes its appearance about the middle of November, when the ſoil has been thoroughly ſaturated with the periodical rains. The gummy juice is ſeen to ooze through the trunk and branches, and in about a fortnight it hardens into roundiſh drops of a yellowiſh-white, which are beautifully brilliant where they are broken off, and entirely ſo when held in the mouth for a ſhort time to diſſolve the outer ſurface. No clefts are made nor any artificial means uſed by the Moors to ſolicit the flow of the gum. The lumps of Gum-Senegal are uſually about the ſize of partridge eggs, and the harveſt continues about ſix weeks. The quantity annually ſold out of the Senegal country for European conſumption is about twelve hundred thouſand pounds weight.

This gum is alſo a very wholeſome and nutritious food, thouſands of the Moors ſupporting themſelves entirely upon it during the time of harveſt. About ſix ounces is ſufficient to ſupport a man for a day, and it is beſides mixed with milk, animal broths, and other victuals.

The Gum-Arabic, or that which comes directly from Egypt and the Levant, only differs from the Gum-Senegal in being of a lighter colour and in ſmaller lumps, and it is alſo ſomewhat more brittle. In all other reſpects the two reſemble each other perfectly. Its ſpecific gravity is about 1.45.

The uſes of this gum are very great and numerous. The greateſt conſumption of Gum Senegal is in furniſhing a thick viſcid fluid with which the different mordants are mixed in calico-printing, which has been more particularly deſcribed in the article *Dyeing*.

Another great uſe of Gum-Arabic is in giving a fine gloſs or glazing to ribbons and ſilks. For this purpoſe a thin ſolution is made, and the ſilk ſlightly bruſhed over with it, and when dry it leaves a very thin colourleſs varniſh, but readily waſhed off by water, whence the ſpotted appearance that a ſhower of rain gives to theſe articles. Gum-Arabic is alſo uſed as a clean, convenient, and pretty ſtrong cement for an infinite number of purpoſes where there is no riſk of moiſture. Its ready ſolubility in water and the length of time which the ſolution will keep without ſpoiling, render it highly valuable in the arts.

This gum is alſo employed in pharmacy as a very convenient way of rendering miſcible with water, oils, reſins, and other ſubſtances on which water alone has no action. The effect here is chiefly mechanical. The ſubſtance (olive oil for example) is to be well rubbed with about half its weight of a ſtrong ſolution of gum, and the watery liquid afterwards added by degrees and with conſtant rubbing, and by this method an opake emulſion is formed, in which the ſubſtances will remain mixed for many hours, nor will they again entirely ſeparate.

To obtain the gum-mucilage from thoſe vegetables that do not yield it by exſudation, recourſe muſt be had to boiling with water and evaporation. Theſe kinds of mucilage however will ſeldom anſwer as cements, as they will not ſufficiently harden by drying, and they are more liable to mould, and to become brown and coloured during the requiſite evaporation.

Lord Dundonald[b] has given the following directions for preparing the mucilage from the lichen. This plant is the common large-leaved moſs that grows ſo abundantly on foreſt and fruit trees, and in the North of Europe and America, it grows to the length of a foot or more, giving a nutritious food to deer and other animals. The lichen has an outer ſkin, and below this a green reſinous ſubſtance; and the remainder of the plant conſiſts chiefly of gum and of fibrous matter on which water has no action. To ſeparate the outer ſkin and the reſinous matter the plant muſt be ſcalded two or three times with boiling water, whereby the ſkin cracks, ſwells, and peels off. After this it is to be put into a boiler with about three quarts of water for every pound of the plant, and about half an ounce of potaſh or ſoda (which aſſiſts the extraction) and the boiling ſhould be continued till the liquor acquires a conſiderable degree of gummy conſiſtence. The liquor is then to be taken out and ſtrained from the plant, and freſh water added to the ſame material, further to exhauſt the gum. The ſeveral liquors, after ſtanding ſome hours to ſettle, and then removing the dregs, are to be boiled down in a regulated heat to the conſiſtence which is required for uſe, but not further, leſt it ſhould burn and become coloured. It requires two or even three boilings entirely to exhauſt the lichen of its mucilage.

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[a] Golberry's Travels in Africa.

[b] Phil. Mag. vol. x.

The method to be purſued in extracting the mucilage from other plants is ſo ſimilar that nothing more need be added on the ſubject. The ſubſtances the moſt likely to interfere with the purity of the gum in thoſe ſucculent plants that abound with mucilage, are for the moſt either inſoluble in water or coagulable at a boiling heat; ſo that a judicious management of the boiling and clarification will generally ſucceed with thoſe vegetables where the mucilage is in ſufficient quantity to repay the trouble of extraction.

Another ſpecies of native mucilage, ſomewhat differing from any of the preceding, is gum tragacanth. This is a white opake gum, in the form of twiſted ſhreds, ſeldom free from viſible impurities, and of a remarkably tough almoſt horny conſiſtence, ſo that it cannot be reduced to fine powder without conſiderable labour. It exſudes from the ſtem and branches of a very thorny ſhrub (*Aſtragalus Tragacantha.* Linn.) which grows on the iſland of Candia, and other parts of the Levant.

The juice dries in the ſun, and being collected by the ſhepherds, is ſent to Europe without any preparation. It differs from Gum-Arabic in being, properly ſpeaking, hardly ſoluble in water, but when it is covered with water it ſwells prodigiouſly in the courſe of ſome hours, and abſorbs ſo much of the fluid as to become ſoft and pulpy, but will not reſolve itſelf into a liquid by any further addition of water. In this ſoft pulpy ſtate it will readily mix with other mucilages, and may be ſpread thin over any ſurface, and it then dries into a very firm cement. It is employed much in book-binding, mixed with paſte, and is found to make a very ſtrong cement.

We proceed to the chemical properties of mucilage in general. When a mucilage (Gum-Arabic for example) is diſtilled *per ſe* in veſſels arranged ſo as to detain all the products, there firſt comes over ſome pure water, which is immediately followed by a reddiſh-brown acid liquor, mixed with a little browniſh oil and much carbonic acid gas and carburetted hydrogen. This acid liquor is very ſour to the taſte and has an empyreumatic ſmell, and has been called the pyro-mucous acid. It is altogether produced by the action of fire, as the mucilage in its natural ſtate gives no indication whatever of acidity. The ſame acid is produced by the diſtillation of ſugar, farina and many other vegetable matters.

The pyromucous acid is incapable of cryſtallizing or aſſuming the ſolid form. It riſes very readily at a boiling heat, and has a ſtrong, pungent, burnt, acid taſte. It may be concentrated by freezing in the ſame manner as common vinegar. It unites with the alkalies and earths, and with ſeveral of the metallic oxyds, forming ſalts which in the properties of eaſy or difficult ſolubility, cryſtallization, &c. reſemble very cloſely the correſponding ſalts formed with the acetous acid; and from the analogy of the other empyreumatic acids it appears probable that the pyromucous is chiefly acetous acid intimately united by diſtillation with empyreumatic oil and other products of the mucilage altered by fire.

The action of the nitric acid upon gum-mucilage has excited ſome attention on account of the many new products formed by the mutual decompoſition of theſe ſubſtances, and particularly the formation of a peculiar acid, the Mucous. This acid is found to be the ſame as that diſcovered by Scheele to be produced by the action of nitric acid on ſugar of milk, which has been partially deſcribed under the article *Milk*.

When nitric acid is moderately heated with half its weight of gum-arabic, only till nitrous gas begins to be diſengaged, there depoſits on cooling a white powder, which when collected and waſhed is the mucous acid.[c] It has a granular feel and taſtes ſlightly ſour. When heated

[c] Fourcroy.

per ſe to decompoſition it gives a red ſharp-taſted oil, much carbonic acid gas, and a portion of it ſublimes in brown ſcales ſmelling like the benzoic acid. The dry mucous acid is very ſparingly ſoluble in water. The hot ſaturated ſolution depoſits on cooling brilliant ſcaly cryſtals. It decompoſes the carbonated alkalies at a boiling heat, expelling the carbonic acid and forming perfectly neutral ſalts.

The acid of ſugar of milk or the ſaccholactic acid (according to Scheele[a]) forms with carbonat of potaſh ſmall cryſtals that require eight times their weight of boiling water for ſolution, but moſt of the ſalt is depoſited on cooling. The ſaccholat of ſoda is much more ſoluble, hence if to a ſaturated ſolution of this ſalt ſome potaſh be added, a copious depoſition of ſmall cryſtals of ſaccholat of potaſh takes place owing to the ſuperior affinity of the acid for potaſh. The ſaccholactic acid forms with all the earths ſalts inſoluble in water, and hence it decompoſes the ſoluble ſalts of the ſame earths, ſuch as the nitrats or muriats, and forms a white ſaline precipitate with them. It alſo decompoſes in the ſame manner the ſolutions of ſilver, mercury, and lead.

When the acid liquor, which remains after the ſaccholactic acid has been depoſited from the ſolution of ſugar of milk in nitric acid, is boiled with a freſh quantity of acid and evaporated, a large quantity of long cryſtals are formed on cooling, which Scheele found to be oxalic acid, and by adding ſufficient nitric acid the whole reſidue may be thus changed. This led to the opinion that the white powder deſcribed as the ſaccholactic acid was only oxalat of lime, but it was found by this excellent chemiſt that ſugar of milk itſelf contained no lime, ſince it gave no precipitate with oxalic acid, and hence this conjecture was erroneous.

Fourcroy has ſome curious and valuable facts on the correſponding decompoſition of gum-mucilage by nitric acid. If the proceſs above deſcribed, viz. of ſimply heating gum with nitric acid till nitrous gas is given out and mucous acid depoſited, be carried no further, the clear liquor from which the mucous acid has ſubſided contains in that ſtate no oxalic acid but only the *malic*, which, as mentioned under that article, is generally the preceding ſtep in oxygenation to the oxalic. Hence it cannot be made to aſſume a cryſtalline form by evaporation, but when concentrated by heat the liquor becomes intenſely ſour and brown or red. It precipitates lime from lime-water, but the precipitate is again ſoluble in an exceſs of the ſame acid, a character which particularly diſtinguiſhes the malic acid from the oxalic, and the latter acid alſo produces its own calcareous ſalt by being added to the acid ſolution of malat of lime.

A further addition of nitric acid aſſiſted by heat completes the converſion of this malic acid into the oxalic.

The mucous acid is not of itſelf alterable by any further treatment with nitric acid, but it is a truly curious phenomenon of complicated chemical affinities that nitric acid and gum, two homogeneous ſubſtances, ſhould by their mutual action at the ſame time produce two acids ſo decidedly different as the mucous and the malic, and not convertible the one into the other by any further action of the ſame acid to which they owed their formation.

If the concentrated ſulphuric acid is poured on gum-arabic, it chars and blackens it, and converts a portion into acetous acid. The muriatic acid alſo produces the acetous, but more ſlowly. The weaker acids ſimply diſſolve gum, but do not alter it.

In the analyſis of vegetable matter the mucilage that exiſts in combination with the other principles may generally be obtained in tolerable purity by the combined action of water, heat, and alcohol. The vegetable, if dry, readily yields its mucilage to the ſimple action of water, then, as mucilage is not coagulated by heat, a boiling temperature will ſeparate the albumen and ſome other principles ſoluble in water, but coagulable by heat. After this the clarified ſolution ſhould be concentrated by ſlow evaporation till it is of a ſlimy conſiſtence, when on the addition of three or four times the bulk of rectified alcohol, the whole of the mucilage will ſeparate in the form of a white powder, and the alcohol boiled on it will take up any reſinous matter which the water had previouſly diſſolved by help of the gum. The alcohol will alſo take up the acetite of potaſh which frequently exiſts in vegetable juices, but will precipitate it along with the mucilage, the phoſphats, and ſulphats, and muriats. The precipitated mucilage is again ſoluble in water, and by ſlow evaporation may be dried to its proper ſemi-tranſparent gummy form, but the above ſalts if ſoluble in water (if perfect accuracy is required) muſt be ſeparated, or their quantity eſtimated by diſtinct proceſſes. As a general obſervation it may be remarked that the conſtituents of organiſed matter, particularly the ſoft ſoluble parts, are ſo intimately blended that it uſually requires a repetition of the ſame chemical means uſed to ſeparate them; ſo in the preſent inſtance it would probably require the ſolution of mucilage to be twice ſucceſſively precipitated by alcohol before the ſeparation was compleat.

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[a] Eſſays.

Several intereſting experiments on the intimate nature of mucilage have been made by Mr. Cruikſhank, which we ſhall partly notice in this place, and partly refer to the article *Sugar*. Sugar, as Mr. C. obſerves, has been thought to be a ſubſtance of intermediate oxygenation between mucilage and the vegetable acids. Hence it would follow that mucilage and ſugar are convertible into each other by a due addition or abſtraction of oxygen, ſuppoſing that the proceſſes of nature can be at all imitated in the laboratory. That ſugar is formed out of mucilage in natural proceſſes appears obvious, for the plants that yield ſugar at a certain period of their growth, only contain mucilage at an earlier period. The proceſs of germination alſo (particularly of barley by malting) decidedly converts mucilage into ſugar. By many experiments on the growth of barley in cloſed veſſels and in atmoſpheres of different gaſſes, Mr. C. uniformly found that oxygen was neceſſary to the germination of the ſeed, and that in the proceſs much carbonic acid was produced. This oxygen may be either abſorbed entirely or may immediately combine with the carbon of the ſeed to produce carbonic acid. Mr. C. then endeavoured to invert the proceſs, and to convert ſugar into gum by a *diſoxygenating* proceſs. Phoſphuret of lime was choſen for this purpoſe. Some ſugar was diſſolved in alcohol, and phoſphuret of lime added. No gas was diſengaged, and the mixture ſtood in an open phial for ſome days. The alcohol was then evaporated and water added, which would have diſengaged phoſphuretted hydrogen had the phoſphuret remained unaltered, but this was not the caſe, as it was now converted into phoſphat of lime from the abſorption of oxygen (as Mr. C. ſuppoſes) from the ſugar. The clear liquor being then evaporated there remained a very tenacious ſubſtance, bitter to the taſte, with ſcarcely any remaining ſweetneſs; when ſqueezed between the teeth it had exactly the feel of gum but was more tenacious. It was no longer ſoluble in alcohol (as ſugar is) and when thrown on a red hot iron it burned like gum, and left an inſipid bulky charcoal.

The converſe of the above experiment was then tried, but it was not found that gum could be converted into ſugar by any oxygenating proceſs, the action of the nitric and oxymuriatic acids on gum being to generate acids (as already related) but not ſaccharine matter.

Some further experiments on the ultimate analyſis of mucilage may be extracted from the ſame author.[e] One ounce of gum-arabic diſtilled *per ſe* in a glaſs retort, gave 3 drams 30 grs. of pyromucous acid mixed with a little heavy oil and a very large quantity of gas. The coal left after a red heat had been continued for ſome time, weighed 106 grs. which when burnt to aſhes in an open crucible left 10 grs. of a white powder, conſiſting of phoſphat of lime and ſome exceſs of lime. The pyromucous acid being ſuper-ſaturated with lime, a ſtrong ſmell of ammonia was perceived, ſhewing that azot, one of its conſtituent parts, muſt have previouſly exiſted in the gum. The gas furniſhed by the diſtillation amounted to 273 ounce meaſures, of which 93 were carbonic acid, and the remainder was hydro-carburet, of the ſame kind as that produced by burning moiſtened charcoal.

An ounce of gum-tragacanth treated in the ſame way, afforded 4 drams 5 grs. of pyromucous acid, and 105 grs. of charcoal, the calcareous aſh of which after incineration amounted to 12 grs. and was, as in the former caſe, lime mixed with phoſphat of lime. The ammonia procured from the pyromucous acid was in much greater quantity than from gum-arabic.

An ounce of gum-arabic treated with nitric acid alſo afforded 3 drams and 36 grs. of oxalic acid, and 6 grs. of a white powder which Mr. C. affirms to be oxalat of lime, and not mucous acid as repreſented by other chemiſts, but he does not give the experiments by which this was aſcertained.

Gum mucilage is not ſuſceptible alone of the vinous fermentation, for Mr. C. found that when mixed with yeaſt, and kept for a long time at a warm temperature, nothing like fermentation could be perceived, and the mixture though it acquired a nauſeous ſmell, retained its original taſte. It is only when unmixed however that mucilage remains ſo inactive, for when united with ſugar either naturally or artificially, it forms a compound in which fermentation is eaſily excited.

MUCILAGE, *Animal* or *Animal Mucus*.

Many of the animal fluids contain a ſubſtance which reſembles vegetable mucilage in being ſoluble in water, not coagulable by heat, inſoluble in alcohol, inſipid and giving a ſlimy conſiſtence to the fluids with which it is mixed, and hence is denominated mucus. The ſaliva is a familiar example of a mucilaginous animal fluid. Animal mucus reſembles gelatin ſo cloſely both in its ultimate analyſis and in many other properties, that the one is conſidered by Mr. Hatchett as only a modification of the other, and moſt of what has been deſcribed in the article Gelatin will therefore apply here.

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[e] Cruikſhank in Rollo's Eſſay on Diabetes, or Nich. Phil Journ. 4to. vol. i. and ii.

Dr. Boſtock[a] has however very clearly pointed out a very decided difference between the two in the manner in which they are acted on by the aqua lithargyri acetati, or Goulard's extract, a preparation of lead, made by ſaturating boiling vinegar with litharge. This liquor when added to any fluid containing animal mucus, gives a copious white precipitate, whereas it is not rendered ſenſibly turbid by a ſolution of pure jelly.

The infuſion of galls or tan alſo which inſtantly precipitates jelly, has no effect or ſcarcely any on mucus, and theſe two teſts therefore will be ſufficient in moſt inſtances to detect the preſence of one or the other. Neither mucus nor gelatin are altered by the ſolution of corroſive ſublimate, which however precipitates albumen copiouſly. Hence in a mixture of albumen, gelatin and mucus, theſe ſubſtances may be ſeparated with tolerable accuracy by the ſucceſſive application of corroſive ſublimate, infuſion of galls, and acetated litharge.

It is not eaſy however to find the exact quantity of mucus by the ſolution of litharge, for the lead which it contains will be equally precipitated by ſulphuric, muriatic, and phoſphoric ſalts, all of which are found in many animal fluids. A further application of reagents might indeed ſeparate the ſulphat, muriat, and phoſphat of lead, from that peculiar combination formed by mucus and oxyd of lead, but the quantities of each are generally too ſmall to allow of much accuracy in this mode of proceeding.

Animal mucus is generally combined with gelatin and albumen, and always with ſome ſalts, and on the whole it is one of the leaſt abundant of the animal fluids.

MURIATIC ACID. *Acide Muriatique*, Fr. *Salzaure*, Germ.

If a ſmall retort or a proof bottle with a curved tube be half filled with well dried common ſalt, and ſome ſtrong ſulphuric acid be poured upon it, a copious effervefcence takes place, and the elaſtic fluid thus extricated appears in the form of a white vapour as ſoon as it comes in contact with the atmoſphere: when by the evolution of this gas all the common air has been driven out of the retort, the ſubſequent portions of gas may be collected in the uſual manner in glaſs jars filled with mercury and inverted in a bath of the ſame fluid. The air thus procured is known among chemiſts by the name of muriatic acid gas; it is tranſparent, colourleſs, and poſſeſſed of the ſame mechanical properties as common air and other elaſtic fluids. Its ſpecific gravity, according to Fontana, is about = 0.00209, but according to Kirwan, is = 0.00231, that of water being = 1000.0, and of atmoſpheric air = 0.00123. It has a peculiarly ſuffocating odour; to the taſte is extremely ſour and corroſive, and affects vegetable colours in the ſame manner as other acids. It is inſtantaneouſly fatal to animal life, and is incapable of ſupporting combuſtion; this peculiarity however belongs to it, that if a lighted taper is plunged into a jar full of it, the flame is conſiderably enlarged and tinged of a greeniſh yellow colour before it is extinguiſhed.

Muriatic acid gas is not, properly ſpeaking, combuſtible, though it unites without difficulty with a conſiderable proportion of oxygen, forming OXYMURIATIC ACID. The affinity between water and muriatic acid is very powerful: even when this ſubſtance is in a gaſſeous ſtate it holds a conſiderable quantity of water, from which it cannot be freed otherwiſe than by the decompoſition of this latter ſubſtance. If a little water be introduced into a jar of muriatic acid gas ſtanding over mercury, an immediate abſorption takes place and the whole of the acid ſuddenly loſes its gaſſeous ſtate, heat being at the ſame time given out. A ſimilar though not ſo ſudden an effect is produced by charcoal, ſoft wood, ſponge and various other porous bodies, probably in conſequence of their containing moiſture. A piece of ice introduced into muriatic acid gas is melted as rapidly as if it was laid on a hot coal in conſequence of the liberation of caloric during the combination of the water and acid. If alum or any other ſalt containing much water of cryſtallization be introduced into this acid gas, an abſorption takes place and the ſalt becomes pulverulent in conſequence of the transfer of the greateſt part of its water to the acid. Iron filings, wax, phoſphorus, ſulphur and other inflammable bodies when brought into contact with muriatic acid gas abſorb more or leſs of it, and the reſidue after waſhing with water is inflammable;[a] the cauſe of which will be explained preſently when we treat of the decompoſition of this acid. Neither azot nor any of the ſimple or compound inflammable gaſſes have any action on muriatic acid, with ammoniacal gas however it combines inſtantaneouſly, the two airs if rightly proportioned to each other entirely diſappearing and ſolid muriat of ammonia being the reſult.

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[a] Edin. Med. & Surg. Journal.

[a] Prieſtley on Air. Vol. ii. p. 280.

Although muriatic acid when in the ſtate of gas is the pureſt form in which it is known, yet the inconvenience of keeping and applying any ſubſtance in this ſtate being very great, it is always uſed except on particular occaſions in a liquid form. Liquid muriatic acid, or ſpirit of ſalt, is prepared in the following manner. A capacious tubulated retort is filled about one-third of its capacity with decrepitated common ſalt (muriat of ſoda), and the juncture of the retort with the receiver is carefully cloſed with fat lute: to the receiver is adapted a Woulfe's apparatus, the bottles of which are placed in a frame or ſmall ciſtern for the ſake of keeping them cool by means of ice and water. The Woulfe bottles themſelves are more than half filled with diſtilled water, and then concentrated ſulphuric acid, in the proportion of about 6 ounces for every pound avoirdupois, is poured upon the ſalt through the tubulure of the retort, which is immediately after cloſed with its glaſs ſtopper. As ſoon as the acid and ſalt come into contact, the retort and receiver are filled with white vapour, and the diſengagement of muriatic acid goes on for ſome time without the application of heat: when the current of gas through the Woulfe bottles begins to ſlacken, a pot of lighted charcoal ſhould be placed under the retort, gradually increaſing the fire till at a very low red heat no more gas is diſengaged. What remains in the retort is now dry ſulphat of ſoda, and the water in the Woulfe bottles will be found to be more or leſs impregnated with muriatic acid according to the quantity of ſalt originally made uſe of. The method purſued in the manufacturing laboratories in England is in general the ſame as that mentioned above, but with a greater ſimplicity of apparatus, and the veſſel that performs the part of the retort is either of earthenware or of iron; this laſt however is extremely improper, as a portion of iron always riſes with the acid and thus communicates to it that yellow ſtraw colour which diſtinguiſhes common muriatic acid. In Germany, where ſulphuric acid is dearer than it is in this country, the mode of manufacturing this acid is to mingle accurately one part of common ſalt with four of dried clay, and to ſubject the maſs to ſtrong ignition in iron or earthen veſſels; at a high temperature the alkaline baſe of the ſalt combines with the earth, and the gaſſeous acid as it paſſes over is received into water where it is condenſed in the uſual way. [b]

If a portion of water be confined in a jar over mercury, and muriatic acid gas be let up into it, a quantity of gas equal in weight to the water will be abſorbed, while its bulk will be increaſed, according to Dr. Prieſtley, from 1 to 1.5, and according to Kirwan from 1. to 1.33: hence the ſpecific gravity of this liquid acid, according to the former, is = 1.33, and according to the latter = 1.5: but the ſpecific gravity of the ſtrongeſt muriatic acid that can be made and kept in the common method does not exceed at 60° Fahr. 1.196. Pure liquid muriatic acid is as colourleſs as water; when expoſed to the air it emits a white vapour; it affects the ſmell and taſte in the ſame manner as the muriatic gas does: it combines with the alkalies and earths, forming neutral ſalts. Its action upon iron and zinc is very rapid and accompanied by a copious diſengagement of hydrogen gas; at a boiling temperature and in open veſſels it oxydates and diſſolves copper, tin, biſmuth, lead, cobalt, manganeſe, antimony, and arſenic; ſilver is alſo affected by it though very ſlightly; it ſeems to have no action whatever on gold, platina, mercury, tungſten, molybdena, tellurium and titanium. It diſſolves all the metallic oxyds and is an acid of remarkable activity. When heated for ſome time in cloſed glaſs tubes it corrodes them very ſenſibly, taking up the oxyd of lead from the white glaſs and the alkali from green glaſs. [c]

Muriatic acid is capable of decompoſing in part the ſtrongeſt nitric acid, being itſelf at the ſame time converted into the oxygenated muriatic acid, as may be ſeen more at length in the article NITRO-MURIATIC ACID. For the ſame reaſon alſo the alkaline nitrats are decompoſable by muriatic acid, as has been ably ſhown by Cornette. [d]

Various attempts have been made to decompoſe the muriatic acid, and becauſe in moſt of the experiments a quantity of hydrogen made its appearance, this ſubſtance was ſuppoſed by many to be the acidifiable baſe of the acid. From more recent and accurate examinations however it appears highly probable that the hydrogen in all theſe caſes ariſes not from the decompoſition of the acid but of the water, which it always contains in a greater or leſs proportion. The moſt ſatisfactory experiments relative to the ſuppoſed decompoſition of muriatic acid are thoſe of Mr. W. Henry,[e] the principal reſults of which we ſhall proceed to detail. When muriatic acid gas confined in a glaſs jar over mercury is ſubjected repeatedly to the electric ſhock, it undergoes a diminution of bulk, a white matter appears on the inſide of the tube, and upon ſubſequent mixture with water a portion of gas remains unabſorbed, and appears to be hydrogen in a ſtate of conſiderable purity. The diminution of the acid gas and all the other accompanying phenomena are the moſt remarkable when the acid operated upon is that which is firſt diſengaged on mixture of ſulphuric acid and common ſalt: the part that comes over during the latter end of the proceſs is conſiderably leſs affected by the electric ſhock than that which is firſt produced; and if the gas has been previouſly dried for ſome days by contact with ſolid muriat of lime, the diminution of bulk by electrization is ſcarcely perceptible. The white matter that appears during the proceſs is mild muriat of mercury or calomel: hence it is obvious that in theſe experiments oxygen and hydrogen are diſengaged, of which the oxygen together with part of the muriatic acid unites with a portion of the mercury, while the hydrogen and the reſidue of the acid remain in the ſtate of gas. Now as the component parts of water are oxygen and hydrogen, and as the amount of theſe ſubſtances diſengaged by the electric ſhock is in an inverſe proportion to the dryneſs of the gas, it is reaſonable to conclude that the hydrogen and oxygen proceed from the decompoſition of water and not of muriatic acid. This concluſion is further ſtrengthened by another fact, namely, that after a number of ſhocks have paſſed through the gas its diminution ceaſes, and if it is then transferred to a freſh tube over mercury and again ſubjected to the action of electricity, no further change in bulk is experienced, nor is there any formation of calomel; but if the acid were really decompoſed, the production of calomel ought to continue as long as any acid gas remained. Again, when muriatic acid gas is electrified in a glaſs tube without the contact of mercury, the reſult is found to be oxymuriatic acid gas mixed with hydrogen. Several attempts were made by Mr. H. to deoxygenate muriatic acid gas by mixing it with carburetted hydrogen and electrifying it, but without ſucceſs: the mixed gaſſes were indeed expanded and carbonic acid was produced, but theſe changes were obviouſly cauſed merely by the decompoſition of the water, ſince after they had entirely ceaſed a little water was introduced, and the quantity of muriatic acid abſorbed was equal to what would have been taken up if the acid gas had been electrified by itſelf.

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[b] Gren. Syſt. Hand. der Chim. i. p. 467.

[c] Prieſtley.

[d] Mem. de l'Acad. des Sciences for 1778, pp. 44—333.

So various and uniformly ineffectual have been the attempts to decompoſe this acid, that we muſt conclude either that it is a ſimple body, or if, like many other of the acids, it be conſidered as a compound of a combuſtible baſe with oxygen, the affinity between the two muſt be regarded as more powerful than that of any of the known combuſtible bodies with oxygen.

The affinities of muriatic acid are arranged in the moſt recent tables in the following order. Barytes, potaſh, ſoda, ſtrontian, lime, ammonia, magneſia, glycine, alumine, zircon, metallic oxyds. This order however is not correct, for the oxyds of ſilver, mercury, lead, and probably antimony, are capable of decompoſing moſt if not all the neutral and earthy muriats.

The uſe of muriatic acid in the laboratory is very conſiderable, but in medicine and the arts it is but little employed except in the form of muriat or combined with ſome ſalifiable baſe. It is worth remembering by the chemiſt that nothing takes off the cruſt of oxyd of iron, which in many experiments is found adhering with remarkable cloſeneſs to glaſs veſſels, ſo ſafely and quickly as a little warm dilute muriatic acid.

Muriat of Potash, or *Salt of Sylvius.*

Muriat of potaſh is rarely if ever found native except in the aſhes of a few plants and in ſome animal fluids, eſpecially milk. To obtain it pure it muſt be formed either by the direct union of muriatic acid and potaſh, or its carbonat, or by decompoſing common ſalt by potaſh. The former is the beſt method for a chemical inveſtigation of its properties.

If a ſaturated ſolution of this ſalt is ſlowly evaporated the muriat of potaſh ſeparates in the form of regular cubes, which have a ſalt and bitter taſte, together with a degree of pungency like muriat of ammonia. It diſſolves in three times its weight of cold water, and by boiling ſomewhat more is taken up, and hence a clear hot ſaturated ſolution depoſits a portion of ſalt by cooling, in which reſpect it differs from pure muriat of ſoda. Muriat of potaſh when briſkly heated ſharply decrepitates, but does not liquefy in its water of cryſtallization, this being only about 8 per cent. which flies off at a heat below ignition. At a full red heat the ſalt melts, and if the heat is further urged the ſalt itſelf flies off in a white denſe vapour, which however is not decompoſed.

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[e] Phil. Tranſ. for 1800, p. 188.

This ſalt is ſomewhat deliqueſcent in a moiſt air. If a little ſulphuric acid is poured on it the muriatic acid is expelled in the form of white fumes. The nitric acid decompoſes it partially and cauſes the evolution of nitro-muriatic acid. The phoſphoric acid alſo expells the muriatic at a high heat.

This ſalt is compoſed according to Kirwan, of 64 of potaſh and 36 of acid when dried at 80° of which however about 8 are mere water of cryſtallization; and 100 parts of the ſalt when decompoſed by nitrat of ſilver give 217.65 of dry luna cornea.

Muriat of potaſh is not uſed. It is rarely produced in the large way in chemical proceſſes except when the comparative prices of potaſh and ſoda make it worth while to procure ſoda from ſea ſalt by means of potaſh, as will be mentioned in the next article.

Muriatic acid may be procured from muriat of potaſh in the ſame way as from muriat of ſoda, but the bitter taſte and rather greater deliqueſcence of the former, render it probably ſcarcely fit for any of the culinary uſes of common ſalt.

Muriat of Soda. Sea Salt. *Common Salt.*

This ſalt exiſts abundantly native either as a ſolid foſſil or diſſolved in water. In the former caſe it ranks as a peculiar mineral ſpecies, and will be deſcribed accordingly.

Rock Salt, or Fossil Salt, or Sal Gem.—*Steinſalz.* Wern. *Sel gemme.* Broch.

Of this ſpecies there are the two following varieties.

Var. 1. Foliated Rock Salt.

Its colour is uſually greyiſh, yellowiſh, or milk-white, or aſh-grey, ſmoke and pearl-grey. It alſo though rarely occurs fleſh, blood or brick red, and ſtill more rarely violet or ſky-blue or green. It is found in maſs, diſſeminated, in large columnar or ſpherical diſtinct concretions, or cryſtallized in cubes. The recent fracture is brightly ſhining with a luſtre between vitreous and reſinous. Its fracture is ſtrait foliated in three rectangular directions; hence the form of its fragments is cubical, but this is the caſe only when it is cryſtallized, the maſſive varieties are thick foliated approaching to ſlaty, and break into blunt-edged irregularly wedge-ſhaped fragments. It is ſemi-tranſparent, paſſing on one hand into tranſlucent and on the other into tranſparent. It is moderately hard and not very brittle. To the touch it is ſmooth and almoſt greaſy. Sp. gr. 2.14. It is ſalt to the taſte, it is deliqueſcent in a moiſt atmoſphere, is readily ſoluble in water, decrepitates ſtrongly when laid on hot coals, and is fuſible at a low red heat.

Var. 2. Fibrous rock ſalt.

Its colour is greyiſh-white, yellowiſh or pearl-grey, lavender or violet-blue, or fleſh-red. Its internal luſtre is pearly varying from ſhining to gliſtening. Its fracture is fibrous, either parallel, with fine and curved fibres, or divergent, with coarſe and ſtrait ones. Its fragments are wedge-ſhaped or ſplintery. It varies from tranſlucent to ſemi-tranſparent: it is tender and brittle: in other reſpects it agrees with the preceding variety.

Rock ſalt forms a peculiar ſpecies of rock, the proper geological ſituation of which is between the oldeſt ſecondary gypſum and ſecondary ſandſtone: it forms continuous beds of great thickneſs, and often occurs in large ſolitary blocks: it is always accompanied by ſemi-indurated clay, for the moſt part ſtrongly impregnated with ſalt; and alternates with beds of ſwineſtone, gypſum, limeſtone, and ſandſtone. The beds of ſalt are moſtly below the ſurface of the ground, but ſometimes it riſes into hills of conſiderable elevation. At Cordova in Spain, according to Bowles, there is a hill between four and five hundred feet high, compoſed entirely of this mineral.

Rock ſalt, though not of very frequent occurrence, is however by no means rare; the moſt celebrated mines are thoſe of Wielicza in Gallicia, of Halle in the Tirol, of Poland, of Caſtille in Spain, and Cheſhire in England. In the province of Lahor in Hindoſtan, is a hill of rock ſalt of equal magnitude with that near Cordova. The mines of Iletſki in Ruſſia, yield vaſt quantities of this ſubſtance; it is ſo plentiful in the deſart of Caramania and the air is ſo dry, that it is there uſed as a material for building: it forms the ſurface of a large part of the Northern deſart of Lybia, according to Horneman; it is alſo found in abundance in the deſarts of Peru.

Muriat of ſoda has a pure ſaline taſte without any mixture of bitterneſs. It cryſtallizes in cubes when obtained by ſlow evaporation from its ſolution, but when procured by a boiling heat (as is the caſe with moſt of the ſalt uſed for culinary purpoſes) the form is that of a hollow inverted pyramid, reſembling a hopper, and is made by a ſucceſſive aggregation of cubes round a central one, whilſt floating on the ſurface of the brine, whilſt the increaſing bulk of the maſs cauſes it gradually to ſink lower in the liquor.

Common ſalt is very ſoluble in water, 8 parts of the latter will diſſolve ſomewhat leſs than 3 of ſalt at a moderate temperature, and ſcarcely any more is taken up at a boiling heat, ſo that no ſalt can be obtained from a hot ſaturated ſolution by mere cooling, but only by evaporation of the fluid. Salt contains but little water of cryſtallization, and hence when thrown in the fire or ſuddenly heated it decrepitates or flies to pieces with a crackling noiſe. If heated red hot it melts, and at a ſtill higher temperature it flies off in the form of denſe white fumes, but is not decompoſed by volatilization.

It is compoſed according to Kirwan, of 53 per cent. of ſoda, and 47 muriatic acid and water, and the quantity of real acid is ſuch that 100 parts of the cryſtallized ſalt decompoſed by nitrat of ſilver, will give 233½ of luna cornea,[a] of which the mere acid is 38.6.[b] It muſt be obſerved that there is ſome difference in the analyſes of different chemiſts, but taking the above data as correct, 100 parts of cryſtallized muriat of ſoda will contain 53 of ſoda, 38.6 of acid, and 8.4 of water.

Common ſalt is generally ſaid to be inſoluble in alcohol, however Mr. Kirwan found that in a moderate temperature 100 grs. of alcohol, at .900 ſp. gr. diſſolved 5.8 grs. of ſalt; the ſame quantity at .872 ſp. gr. diſſolves 3.6 grs; and even at .834 ſp. gr. it diſſolved ½ a grain.

Muriat of ſoda may be decompoſed in a variety of ways: its acid is readily and totally expelled by the ſulphuric at a moderate heat: its alkali may be procured by a variety of methods, many of which are uſed in the great way, and will be ſhortly deſcribed at the end of this article.

We now proceed to the mention of methods by which are procured the immenſe quantities of common ſalt employed by man in almoſt every country on the face of the globe.

It has been already mentioned that native ſalt is found, either ſolid, under the ſurface of the earth (when it is often termed ſal gem, and of which that in the county of Cheſter in this country is a ſtriking example) or diſſolved in natural brine ſprings, which are always found in the neighbourhood of rock ſalt: or it is left by the ſpontaneous evaporation of many inland lakes and pools in different parts of the world: or laſtly, an inexhauſtible ſtore of it is contained in the waters of the ocean. Sometimes the rock ſalt is found ſufficiently pure to be uſed without any preparation; this however is rare, for by far the greater part of the ſalt uſed throughout the globe, is got by evaporation of ſalt water, either by natural or artificial heat, or often by both. The general proceſs of making ſalt from brine by artificial heat, is very ſimple and obvious, being little elſe than putting the brine into a broad ſhallow iron pan, bringing it to a boiling heat by furnaces underneath, and continuing the evaporation nearly to dryneſs, during which the ſalt gradually ſeparates as the water is diſſipated, and is afterwards collected and gently dried. But there are ſeveral circumſtances relating to ſalt-making which deſerve the attention of the chemiſt, and require to be related more at large.

We ſhall give in a few words the proceſs of ſalt-making as practiſed in Cheſhire, being the place whence moſt of the ſalt uſed in this country is obtained.[c]

The brine is firſt pumped up from very deep wells, by powerful machinery, and is diſcharged in a large pond or reſervoir. If the brine is weak in ſalt, it is generally ſtrengthened and nearly ſaturated by throwing in a quantity of the more impure rock ſalt dug up in the neighbourhood, particularly in thoſe ſalt-works that have the convenience of water-carriage from the pits. There is a conſiderable difference in the purity of the brine from different pits, all contain a ſmall portion of earthy ſalt, chiefly ſulphat of lime, and a ſmall quantity of carbonat of lime held in ſolution by an exceſs of carbonic acid, and frequently alſo a little carbonat of iron. The pureſt brine is perfectly limpid, of a pure ſaline taſte, and a peculiar cold green hue. This laſt indicates the abſence of iron, for when even the ſmalleſt admixture of oxyd of iron is preſent, the water has a yellowiſh caſt, and the ſalt made from it never acquires that delicate blue-whiteneſs which is conſidered as a criterion of its perfection. The ſalt-pans where the brine is boiled down are oblong ſhallow troughs of wrought iron, uſually from 20 to 30 feet long and broad, and about 9 to 12 inches deep. They are ſet ſtrongly upon maſonry, over a large furnace, the flues of which draw all round the pan. The fuel is coal, of which there are many pits at no great diſtance. Each pan ſtands in a ſmall covered building, with a pyramidal roof formed of boards ſloping downwards, but with a conſiderable interval between each, ſo as to keep off the rain, and at the ſame time to allow of a free paſſage for the ſteam of the boiling brine.

[a] Klaproth. [b] Kirwan, Min. Waters. p. 239. [c] Original Communication.

The whole proceſs of boiling, purifying, and evaporating the brine, is performed in this ſingle pan.

The brine after ſtanding ſome days in the reſervoir, is pumped into the pan. When heated to about 100° it begins to grow turbid, owing to the depoſition of the carbonat of lime and of iron (if any) by the expulſion of the carbonic acid which held them in ſolution. This forms a ſcum on the ſurface of the brine which is partly removed by a ſkimming diſh, but much of it falls to the bottom, and if ſuffered to remain would materially injure the quality of the ſalt. To clear it out the brine is evaporated till it begins to *ſalt*, that is, till a portion of the muriat of ſoda begins to ſeparate, and this falling to the bottom mixes with the carbonat of lime and gives it a body, which enables the workman to draw it out. This is carefully done, and the ſediment thus obtained (called *clearings*) is thrown away, which from a pan of 24 feet by 27, uſually amounts to about three or four buſhels. The evaporation is then continued at a boiling heat, and the ſalt gradually collects at the ſurface and falls to the bottom in beautiful cryſtals of a pure and delicate white, where the brine is good. As the proceſs advances and the ſalt collects in quantity, it is fiſhed out from the bottom of the pans by wooden veſſels, and poured into large hollow wooden cones, with a hole at bottom, and ſuſpended round the ſide of the pans. Here it drains, and the drainings drop again into the pans. When the proceſs is compleated and the contents of the pan evaporated almoſt to dryneſs (which uſually takes a ſingle day and a night) the cones full of the ſalt are taken to a large room made very hot by ſtoves, where they remain till thoroughly dry.

The grain of the ſalt is determined by the rapidity of the evaporation and the degree of heat uſed. In the common ſalt-making the water is evaporated at a full boiling heat, that is, as faſt as poſſible, and hence the grain is ſmall, and the ſalt comparatively ſoft. The contents of a ſingle pan are uſually worked off in twenty-four hours, except from Saturday to Monday, when two days are taken, and hence a larger and harder grained ſalt is made, which is much eſteemed in the country for ſalting cheeſe.

It is found by experience that ſome brines will not readily *ſalt* by mere evaporation, but that ſome addition is required to make them work well and the ſalt fall regularly. This addition is generally calve's feet jelly, ſometimes glue, ſometimes white of eggs, ſometimes blood, and in ſhort any animal or vegetable mucilage ſeems to anſwer the purpoſe. It is uſual to have ſtanding in a corner of the pan an earthen veſſel containing eight or ten pair of calve's feet, to which hot brine is added to extract the jelly, and after the *clearings* are removed and the brine begins to ſalt, the workman adds a little of the jelly at diſcretion. The preciſe uſe of this addition is by no means obvious, nor is it abſolutely neceſſary, but long experience has ſhewn it to be uſeful in many kinds of brine.

Another difficulty ſometimes ariſes. In general the brine when it once has begun to *ſalt*, goes on to work well to the laſt, every part of the ſurface being ſufficiently covered with ſmall cryſtals of ſalt, which ſoon grow into a group forming a ſmall floating iſland of ſalt, which ſoon ſinks to the bottom by its own weight, and leaves a clear ſurface above, which again is covered in the ſame manner. But ſometimes from ſome unknown cauſe, a thick ſhapeleſs cruſt of ſalt forms rapidly over the whole pan, which ſoon hardens to a dry floating cake of ſalt, preventing in a great meaſure the eſcape of the ſteam, and materially retarding the proceſs. To remedy this a ſmall lump of butter, not more than about half an ounce, is thrown into the pan, which quickly melts and diffuſes itſelf over the dry cake of ſalt, and cauſes it to break up and ſink, after which the ſalting goes on well.

After the brine has been evaporated nearly to dryneſs, and indeed during the latter part of the boiling there is depoſited on the bottom and ſides of the pan a hard white ſaline and earthy cruſt, which ſtrongly adheres to the pan, and is partly fuſed to its ſurface by the intenſity of the fire in proportion as the ſides become dry by the loſs of liquid.

This cruſt daily accumulates and produces much inconvenience, partly by injuring the quality of the ſalt, but chiefly by increaſing the diſtance between the fire and the brine, and forming a thick coating through which the heat penetrates with difficulty. Hence it becomes neceſſary about once a month to diſcontinue the boiling for a day, and to pick and beat off this cruſt with hammer and chiſſel often to the great injury of the pan itſelf. The *pickings* or *pan-ſcratch* as they are alſo called are thrown away. Their analyſis will be mentioned afterwards.

A very large-grained and beautiful ſalt is made at Liverpool and ſome other places by very ſlow evaporation of ſaturated brine, and ſtrings or ſticks are put into the pan on which the cryſtals form, as in the making of ſugar-candy. This ſalt is uſed in the curing of fiſh, and is called fiſhery-ſalt.

Much of the fineſt part of the rock ſalt dug out from the pits near Northwich in Cheſhire (the only rock-pits in the kingdom) is exported to Ireland, the Weſt Indies and other parts, and of late years a plan has been adopted of bruiſing it by rollers and bringing the fragments to the ſize of the common bay and fiſhery ſalt, in which ſtate it is found to anſwer well for curing fiſh and meat.

The chemical analyſis of the different brines and products or impurities in ſalt-making will be preſently mentioned.

The above method of ſalt-making has been practiſed in the Cheſhire works with ſcarcely any variation ever ſince their firſt eſtabliſhment, the methods employed in other countries of concentrating weak brine before boiling being unneceſſary here, as there is abundance of ſtrong brine and a further opportunity of ſaturating the weak by the rock ſalt.

As the greateſt inconvenience in ſalt-making is the precipitation of the earthy impurities and the difficulty of preventing them from mixing with the ſalt; a plan has lately been adopted (under patent) in ſome works near Northwich, of heating the brine in a ſeparate pan to the degree at which the earthy carbonats precipitate, before it is ſent into the large ſalting pan. It is found that the ſame fire, by extending the flues, will heat this preparing pan which is contiguous to the other, and the time in which one pan-full is worked off is ſufficient to bring the freſh portion to the requiſite heat, and to purify it conſiderably.

We ſhall now relate ſome of the leading circumſtances of the preparation of ſalt in foreign countries as far as they differ from that above deſcribed.

When a weak brine is expoſed to the atmoſphere the watery part gradually evaporates, and with it the carbonic acid which it contains, the effect of which is to concentrate the ſolution and alſo to cauſe the depoſition of the earth and oxyd of iron which the carbonic acid held diſſolved. As evaporation much depends on the ſurface expoſed to the air, a very ingenious method has been adopted of promoting this by cauſing the weak brine to fall ſucceſſively through large bundles of faggots, whereby a vaſt conſumption of time and fuel in the ſubſequent evaporation is prevented. This operation is called *graduation*, and the place in which it is performed a *graduating houſe*.

This conſiſts of a very long range of rows of faggots placed perpendicularly, and riſing to the height of about 25 feet and diſpoſed in cones, the ſummits of which are about 6 feet in diameter, and the baſes about 10. Juſt above the faggots is a trough perforated with holes at ſmall intervals, furniſhed with ſtop-cocks, and the whole is covered with a pent-houſe roof. At the bottom of the faggots is another trough to catch the brine. The length of theſe houſes is determined by the quantity of brine wanted, ſometimes it is enormous. In ſome parts of Germany there are graduating houſes ſix thouſand feet long, but in general they are from 200 to 1000.

The weak brine is firſt raiſed by pumps to the upper trough, when the ſtop-cocks are turned and the water made to fall like a ſhower of rain through the faggots into the trough below. It is then again forced up and undergoes the ſame operation ſucceſſively till it is ſufficiently concentrated. The ſtate of the atmoſphere has the greateſt influence on the graduation of the brine. The evaporation goes on the quickeſt in a dry air with a moderate wind: when the wind is violent much of the brine is carried away in the ſtate of ſpray or vapour, particularly when the column of faggots is not pyramidal but has the ſame dimenſions throughout. As a proof of this waſte Haller obſerves that in the neighbourhood of theſe graduating houſes the ground becomes in a few years covered with the ſalicornia and other plants which are known to require a ſalt ſoil and flouriſh on the ſea-ſhore.

It has been mentioned that in proportion as the brine becomes concentrated it parts with its carbonic acid, and depoſits carbonat of lime, and hence the faggots of the graduating houſes become gradually encruſted, over every twig, with a brown hard earthy matter, conſiſting chiefly of carbonat of lime. Thus in a courſe of years the faggots are entirely covered with ſtalactite as in the common petrefactions, and the ſurfaces for evaporation become thereby ſo much diminiſhed that it is neceſſary to replace them with freſh faggots. The time that one ſet of faggots will laſt, is about eight or ten years.

The effect of graduation in concentrating brine is very ſtriking. Baron Haller in his valuable memoir on the ſubject gives the reſult of many obſervations on this and other particulars relating to the ſalt-works in Switzerland of which he was the director.[d]

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[d] Mem. de l'Acad. for 1764.

The brine ſprings in this country ſeldom contain more than one per cent. of ſalt in the natural ſtate, but by mere graduation the brine is brought as high as 20 per cent. after which it is ready to be boiled down as uſual. To effect this concentration therefore, 20 parts of brine muſt part with 19 by evaporation through the faggots. The depoſition of ſtalactite hardly begins till the brine is brought to 5 per cent. of ſalt, and it ceaſes altogether when it is brought to 15 per cent. The graduation of the brine becomes ſlower as the concentration increaſes. With regard to the actual effect of a given quantity of faggots, Haller finds that at a mean degree of concentration or 10 per cent. the evaporation of a ſingle day in Switzerland, taking the average of the entire year, is 1100 cubic feet, (reckoning the weight of the cubic foot at 46 lb. of 18 oz.) in a row of faggots 20 feet high, and 735 long. When the ſun ſhines ſtrongly, the exhalation is more than double the above quantity.

A graduating houſe of the above dimenſions is eſtimated to have always at work about 1,912,000 lbs. of brine, and this quantity is furniſhed eleven times in the year to the boiling pans. There appear to be two inconveniences in graduation, one, which is but trifling is, that the brine extracts at firſt ſome colouring matter from the faggots, which is never totally got rid of in the ſubſequent evaporation, ſo that the ſalt has a little browniſh tinge. The other is more ſerious, and it is the actual loſs of brine by graduation either when the wind is too violent, or the proceſs managed unſkilfully and the faggots not well arranged. This in ſome ſalt works is eſtimated as high as from 30 to 40 per cent.

Klaproth has ſome valuable experiments on graduated brines in his analyſis of the ſalt ſprings of Königſborn, which is a ſalt mountain extending from Paderborn to the Dutchy of Cleves, and into the biſhoprick of Munſter. The brine is found much ſtronger the deeper it is drawn. That obtained at 50 feet from the ſurface contains only 1¼ to 2 per cent of ſalt, at 80 feet it is 2¾; and at 120 feet it riſes to 3¼ or 3½ per cent.

The method purſued by this excellent chemiſt in the analyſis of the brine, may be alſo ſhortly mentioned as a direction to the reader who may wiſh to repeat the experiments.

1. Fifty cubic inches of brine (each equal to 290 grs. of diſtilled water) were evaporated to dryneſs in a ſand heat, and the weight noted.

2. The reſidue was covered with alcohol and digeſted in a moderate heat for 24 hours.

3. The alcoholic ſolution was poured off and evaporated to dryneſs, and freſh alcohol poured on the reſidue in order to rediſſolve all the ſalts except the ſmall portion of common ſalt which the firſt alcohol had taken up. The laſt alcoholic ſolution was then evaporated to dryneſs and the reſidue weighed.

4. The dry reſidue from the laſt alcoholic ſolution conſiſted of muriat of lime and muriat of magneſia, and the weight of each was determined in the following manner: the reſidue was diſſolved in water, and the earth precipitated by carbonat of ſoda. This earth, well waſhed, was then combined with ſulphuric acid to exceſs, and after the mixture had ſtood a while in a warm place, the exceſs of acid was abſorbed by adding carbonat of lime. The ſolution was then evaporated conſiderably (removing the ſulphat of lime as it was formed) and then expoſed to exhalation in the open air, whereby the ſulphat of magneſia was ſeparated in cryſtals. Theſe laſt were collected, rediſſolved in water, decompoſed by ſoda, and the magneſia ſaturated with muriatic acid and evaporated to dryneſs. It was then pure muriat of magneſia brought to the ſtate in which it exiſted in the dry reſidue of the brine, and the weight of the muriated lime originally mixed with it was found by ſubtracting the weight of the muriat of the magneſia from that of the entire alcoholic reſidue.

5. The dry ſalt remaining after the ſeparation of theſe earthy muriats was then diſſolved in water and filtered.

6. What was left on the filter conſiſted of ſulphat and carbonat of lime, and oxyd of iron. When weighed, it was treated with muriatic acid, and the ſulphat of lime left on the filter. Ammonia was added to ſeparate the iron which was collected and weighed.

7. The clear ſolution of *No.* 5 might ſtill contain ſulphat of lime; it was therefore boiled with carbonated ſoda, when a carbonated lime fell down. The ſoda added was then neutralized by muriatic acid, and muriat of barytes added, which gave a precipitate of ſulphat of barytes, ſhewing therefore the exiſtence of ſulphuric acid in the brine, which muſt have been combined with the lime obtained by the ſoda. The quantity of ſulphat of lime was inferred from the united weights of the car-

bonat of lime and the ſulphat of barytes, and from the quantity of the latter alſo it was proved that no other ſulphat exiſted than that of lime. The ſame was alſo ſhewn by the gradual ſolution of the ſalt in a mixture of two parts of alcohol and one of water, for the ſulphats will not ſenſibly diſſolve in this mixture without heat.

To ſhew the preciſe effect of graduation we ſhall now give Klaproth's analyſis of brine firſt in its natural ſtate, and then through the ſucceſſive ſtages of concentration in the graduating houſe.

The natural brine was as follows: the ſpecific gravity 1.024:

The entire reſidue from 50 cubic inches weighed 521 grs. which was compoſed as follows:

Muriat of lime - - - -	30 grains
—— Magneſia - - -	½
Carbonated lime - - -	11
Carbonated oxyd of iron -	½
Sulphat of lime - - -	15
Muriat of Soda - - - -	464
	521

This brine was brought by the firſt graduation to the ſpecific gravity of 1.060. The reſidue from 50 cubic inches now weighed 1285 grains, and conſiſted of

Muriat of lime - - - - - -	65 grs.
——— Magneſia - - - -	1½
Carbonated lime with a little iron	4½
Sulphat of lime - - - - -	44
Muriat of Soda - - - - -	1170
	1285

The ſecond graduation brought the ſpecific gravity to 1.076, and the reſidue to 1615 grs. which was compoſed of

Muriat of lime - - -	75 grains
——— Magneſia - -	2
Carbonat of lime - -	3
Sulphat of lime - -	48
Muriat of ſoda - - -	1487
	1615

The third graduation gave a ſpecific gravity of 1.086 and a reſidue of 1850 grains compoſed of

Muriat of lime - - -	82 grains
——— Magneſia - -	3
Carbonate of lime - -	3
Sulphat of lime - - -	52
Muriat of ſoda - -	1710
	1850

By comparing the above analyſes we may infer what muſt be the effect in graduation both in concentrating the brine and in freeing it from a part of its impurities, and what muſt be the compoſition of the ſtalactitical incruſtation on the faggots of the graduating houſe. It would have been more accurate if the ſucceſſive changes produced in an individual brine had been noted, but in the ſalt-works here mentioned there appear to be a number of ſprings all ſlightly differing from each other in the proportion of ingredients, the brine of which is mingled together before graduation. On the whole however it is obvious that the great loſs of the ingredients of the brine is in the carbonat of lime, for ſince the entire reſidue of a given quantity of the rough brine amounts to only 521 grains, and the reſidue of brine thrice graduated is 1850 grains, the proportion of each ingredient (were there no loſs) ſhould be reſpectively upwards of 3½ times as much in the graduated as in the rough brine. Thus the quantity of carbonat of lime ſhould in the graduated brine be about 39 grains, whereas it is actually only 3. This loſs of carbonat of lime therefore ſhould be found in the incruſtation of the graduating faggots, and accordingly this is the caſe; for by analyſis 960 grains of this cruſt contains no leſs than 828 of carbonat of lime. The exact analyſis of this ſubſtance is as follows:

Impure common ſalt - -	4 grains
Sulphat of lime - - -	25
Carbonated oxyd of iron -	92
Carbonated lime - - -	828
Moiſture - - - - -	11
	960

The carbonated oxyd of iron alſo diſappears from the brine during graduation, and is found in the incruſtation.

When the brine is boiled down, what remains of the carbonat of lime in it is precipitated along with ſelenite and common ſalt, and forms that hard cruſt which adheres ſo firmly to the pan, and has been deſcribed already under the term *pickings* or *pan-ſcratch*.

One pound of this analyzed by Klaproth is compoſed as follows:

	oz.	dr.	gr.
Moiſture	1	6	0
Muriated lime	—	1	10
——— Magneſia	—	—	10
——— Soda	4	4	40
Carbonat of lime	1	2	30
Sand	—	3	30
Sulphat of lime	7	6	0
	16	0	0

The *mother water*, or liquor left in the ſalt pan after all the ſalt that it is thought proper to work off is taken out, is a very denſe bitter fluid. Its ſpecific gravity is as high as 1.218. Fifty cubic inches yielded by evaporation 5440 grains of dry ſalt, compoſed of

Muriated lime	660
———Magneſia	840
Sulphat of lime	100
Common ſalt	3840
	5440

It is remarkable that the muriated magneſia is here a fourth more than the muriated lime, whereas in the brine, both rough and graduated, it is not more than $\frac{1}{30}$ or $\frac{1}{40}$ of the muriated lime. Hence much of the latter muſt be decompoſed during the boiling, to which Klaproth attributes the ſtrong ſmell of muriatic acid perceivable when the evaporation is nearly compleated.

A very full and accurate account of all the proceſſes employed in the large ſalt-works of Salins, Moyenvic, and other brine ſprings in Franche Comté in the South of France on the borders of Savoy, is given by Nicolas, who examined them on the ſpot.[e]

We ſhall not tranſcribe it at large to avoid repetition, the general method being that already mentioned, viz. of concentrating the brine by graduation, then boiling down in iron pans. But ſome varieties of practice and other circumſtances contained in this valuable memoir are worth relating.

The brine gives by analyſis the following ingredients. One French pound (of 16 oz. and 576 grs. to the ounce) contains of

	oz.	grs.
Muriat of ſoda	7 —	529
Sulphat of lime		23
Sulphat of ſoda		75
Muriat of lime and magneſia		81

Three kinds of ſalt are made at Salins, namely, large grained, ſmall-grained, and loaf-ſalt. The common or ſmall grained is that which is made at a boiling heat, continued to the laſt. The large-grained is made in ſmall pans placed contiguous to the boiling pans and ſupplied by the ſame fire, the flues being continued under them. The heat in theſe is but ſlow and the evaporation moderate, which allows the ſalt to form in larger cryſtals. The earthy-ſaline ſcum which forms during the boiling, is afterwards lixiviated to extract the ſalt which it contains. The *ſchlot* or *pickings* from the pans contains much Glauber's ſalt which is alſo extracted by hot water, and when the ſolution is ſo far concentrated that it would cryſtallize by cooling, it is ſtirred conſtantly till cold, which makes the ſalt aſſume a needled form like the common Epſom ſalt, and is ſold as ſuch.

A very ingenious plan has been introduced here of applying the principle of evaporation by the atmoſphere, not only to the concentration of the brine but to the actual cryſtallization of the ſalt which it contains. For this purpoſe the brine after common graduation on faggots, is heated in the pan till it begins to ſalt. It is then conveyed to another graduating houſe about 250 feet long, divided by party walls into ſix arches. Theſe ſupport troughs extending the whole length of the building and furniſhed with proper holes for the brine to fall down. The ſpace under each arch is filled with forty rows of endleſs cords ſtretched vertically on wooden frames, each of which contains 25 double cords parallel to each other, and about three inches aſunder. The whole building contains 6000 of theſe double cords about 3 or 4 lines in diameter, and about 30 feet long. The flooring of the building is made of fir planks well put together, and gently ſloping to one end to convey the brine as it falls, into a large reſervoir from which it is again pumped up to the upper trough. The ſide of the building moſt expoſed to the weather is protected by a canvas. The hot brine as it paſſes from the boiler is ſent into the upper trough and then falls down every one of the cords in a copious ſtream, round which the ſalt gradually cryſtallizes in a ſtalactitical form. When the cruſt of ſalt forms a cylinder from 2 to 2$\frac{1}{2}$ inches in diameter it is taken off, and the proceſs repeated. Each operation produces from 3500 to 4000 quintals of excellent ſalt, and requires about a month to be formed; and as this work can only be carried on in the height of ſummer, the cords can be charged no more than twice or at the utmoſt thrice in the year.

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[e] Ann. de Chem. tom. xl.

The ſalt is broken by a kind of moveable flail ſet in a frame in which each row of cords is placed in turn.

The country of Saltzbourg on the borders of the Tyrol furniſhes a vaſt ſupply of ſalt, which is procured from a large ſalt mountain near the town of Hallein. No brine ſprings are found here, which is a remarkable circumſtance, as in general the neighbourhood of rock ſalt abounds in water. The rock ſalt however is not worked out in maſs in this country, but an artificial brine is made in the following manner.[f] A horizontal gallery is cut in the mountain through the middle of the rock ſalt, from 50 to 200 fathoms in length, 5 feet high, and 4 wide. This gallery is ſupported above and on the ſides by planking, and the opening is ſhut up by an earthen wall. Freſh water is then let in from ſprings collected on the upper part of the mountain, till the whole gallery is filled. In two or three weeks the water by reſting on the ſalt has acquired 22 per cent. of ſaltneſs, after which it is drawn off and boiled down as uſual. This proceſs is then repeated as often as neceſſary, till by degrees the galleries by the gradual ſolution of the ſides and floor enlarge into vaſt caverns. The roof never enlarges, which is rather a ſingular circumſtance.

The ſea is an inexhauſtible ſource of ſalt, and vaſt quantities of it are made from ſea-water in different countries. Sea-water is but a weak brine, the ſolid contents of which vary in different parts of the world. In the Baltic it is not more than $\frac{1}{40}$, in the Britiſh Channel about $\frac{1}{30}$, and taken at a great depth near the Equator, it is about $\frac{1}{23}$, in which ſtate its ſpecific gravity is 1.0289, according to Bergman, who has analyſed it. By the experiments of this excellent chemiſt it appears that an Engliſh wine pint of this ſea-water (of 28.875 cubic inches) contained

	grains.
Of Muriated ſoda -	241
— Muriated magneſia	65.5
— Sulphat of lime -	8.
	314.5

A ſmall portion of carbonated magneſia alſo ſeparates during the evaporation.

Sea-water therefore contains a very large proportion of other ſaline matters beſides common ſalt, more ſo than the common brine ſprings, and this being chiefly muriated magneſia, the ſalt procured from ſea-water is apt to be bitter and ſubject to deliqueſcence unleſs a good deal of pains be taken in the boiling, or unleſs the evaporation be conducted very ſlowly. There are ſeveral ways of getting the ſalt by ſea-water: in warm climates this is done altogether by the heat of the atmoſphere, and this forms the large-grained ſtrong dry ſalt called *bay ſalt*, which is preferred to any other for curing proviſions that are intended to keep for a length of time. Bay ſalt is made in great perfection in Spain and Portugal, by the Biſcayans, and on the Mediterranean ſhores of France, and in the Bahama iſlands in the Weſt Indies. The proceſs is ſimple and requires but little apparatus of any kind. The firſt requiſite is a ſea marſh, or ſhallow artificial pond, near enough to the ſea to be filled at high water. A level ſhore muſt therefore be choſen, and the ſoil muſt be clayey to retain the water. The bottom of the pond is then laid out perfectly even, and beaten hard and ſmooth, and a channel with flood-gates is cut to the ſea. The ſalt pools conſiſt always of a large reſervoir communicating directly with the ſea at one end, and at the other with a number of ſmaller pits or beds on which the ſalt is made. The water is firſt evaporated by the ſun's heat conſiderably in the reſervoir, and then conveyed to the ſalt-beds, which are only a few inches deep, and in which the evaporation is compleated alſo by the ſun and wind, and the ſalt ſeparates firſt in the form of a white cruſt which is broken from time to time to expoſe a freſh ſurface to the air. The concentrated brine yields ſalt about twice and ſometimes thrice a week in ſummer. The firſt ſaline cruſt that forms is ſmall-grained, the latter large. Bay ſalt has generally a little tinge of colour, green or brown, according to the ſoil on which it is formed. It is only made in the ſummer months.

Another way of making ſalt from ſea-water, and which is practiſed much on the French and other coaſts of temperate climates, is partly by the atmoſpherical evaporation and partly by boiling, for the ſummers are not hot enough in this climate to make ſalt by mere expoſure of brine to the air. The general mode of proceeding is that already mentioned, that is to ſay, the ſea-water is expoſed during the ſummer in ſhallow artificial pools, where it becomes highly concentrated, and this is afterwards boiled down in iron pans in the uſual mode. This way is adopted largely in Scotland, and in a few parts of England, particularly at Lymington. The mother water that remains after moſt of the ſalt has been extracted, contains much muriat of magneſia, and this is advantageouſly converted into the *ſulphat of magneſia*, as will be mentioned under that article.

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[f] Joural des Mines, No. 76.

There is ſtill another method of extracting the ſalt from ſea-water, which is by collecting the ſand that has been repeatedly moiſtened by the ſea-water and dried, and lixiviating it in reſervoirs, where it forms a very ſtrong brine, which is then boiled down as uſual. This way is much practiſed on the weſtern coaſt of France, particularly in Lower Normandy, and at the iſles of Oleron and Rhé.[g]

The ſpot being choſen (which ſhould be on a level ſhore with a clean ſand) the neceſſary buildings are erected namely, evaporating pans, ſtore-houſes, covered ſheds, &c. and an area of three or four acres is ſelected a little below the level of the ſpring tides and above the neap. The ſurface is carefully levelled by the plough, and rolled ſmooth and hard. It is then filled to the heighth of ſeveral inches with ſand taken from the edge of the ſea at low water, and the ſand is alſo drenched with ſea-water as the tide flows in. It then lies expoſed to the ſun and wind, which ſoon diſſipate the ſuperfluous water, and the ſurface of the ſand appears covered with a white effloreſcence. It is then turned over frequently with a kind of ſhovel, changing the ſurface ſeveral times a day till the whole is thoroughly dry. This ſaline ſand is then carried to the ſheds, and the proceſs repeated with freſh ſand till a large quantity is collected, which generally employes the whole ſummer. To make the ſalt, the dry ſand is taken out of the ſheds and thrown into ſmall round pits about 2½ feet in diameter, and 12 inches deep, the bottoms of which are lined with hard rammed clay mixed with chopped ſtraw, to prevent the water from oozing through. The ſand is then covered with ſea-water, or with the weaker ley of former operations, and after ſtanding ſome hours is drawn off into reſervoirs or barrels, whence the evaporating pans are immediately ſupplied. The ſand is lixiviated a ſecond time, and this ley is reſerved for a freſh portion of ſand. The boilers are of lead, about 3½ feet ſquare, and 4 or 6 inches deep. They are heated with wood of any kind, or ſometimes with reeds, and a boiler of this kind is worked off in from two to three hours. The ſalt is raked out as it forms, and drained in hollow cones, as in other places. Three pans of this dimenſion yield together about 50lbs. of ſalt.

The ſalt procured in this way is white and ſmall grained, but it is very apt to be damp, and is a weak-bodied ſalt little fit for preſerving animal food for any length of time.

In ſome northern countries ſome advantage is made of the effect of cold in concentrating brine, by freezing at firſt only the more watery part, of courſe leaving the unfrozen part proportionably richer in ſalt. The winters of this country are not cold enough in general for this purpoſe, but it is uſed occaſionally on the Baltic coaſts. The cold however muſt not be too intenſe, otherwiſe the brine itſelf freezes. Frozen ſalt water is not in hard ſolid maſſes like freſh water, but it is ſoft and crumbly or rotten. The efficacy of this method of concentrating brine is very conſiderable.

Though much of the French ſea-ſalt is very indifferent, the Dutch refine it into a very excellent ſalt, which is uſed in pickling the herrings for which this nation is ſo juſtly famous, and which trade is under the ſtricteſt inſpection as to the goodneſs of the ſalt, and the care to be taken in every ſtep of the buſineſs. It is not preciſely known whether the Dutch do any thing more than boil the ſalt again and evaporate ſlowly, except that it is the conſtant cuſtom when the brine begins to ſalt, to add a ſmall quantity of very ſour whey, which is found by experience to be a very important addition.

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It has been ſuppoſed by ſome eminent obſervers that when a conſiderable depth of brine not ſaturated, remains at reſt for a time, there is a gradual but inviſible ſubſidence of the ſalt, ſo that the lower part of the column of brine will be ſenſibly ſalter than the upper. To this has been attributed the increaſe of ſaltneſs in the ſea, in proportion to the depth whence the water is taken. With regard to land brine-ſprings, it is indeed certain that the deepeſt are uſually much the ſalteſt, but this may be readily accounted for from the conſtant infiltration of freſh water which almoſt always lies above the ſalt rock, and ſometimes in vaſt quantity. Hence it is neceſſary in moſt places (as in Cheſhire for example) to line the ſides of the brine well with very ſtrong planking, and even this cannot entirely keep out the freſh water, which always finds ſome way in.

But an experiment of Haller ſhews that there is actually a ſubſidence of ſalt, or at leaſt ſomething takes place which produces a ſimilar effect. For this purpoſe he made and fixed up vertically a tube of tinned iron, 33 feet high, and filled it with brine containing 12 per cent. of ſalt, and cloſed the top. In two months it was opened. Fifteen inches of liquid had oozed out, the brine at the ſurface (or 15 inches below the level when put in) gave only 9½ per cent. of ſalt, at 11 feet lower it was nearly the ſame, but at the bottom, or 33 feet, it gave 14⅞ per cent. This difference however is too ſmall to promiſe any advantage in concentrating weak brines by mere ſubſidence.

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[g] Journ. des Mines. No. 7, p. 61. and Ency. Meth. Arts & Metiers, Article *Salines*.

The ſame excellent obſerver has given a ſeries of accurate obſervations on the ſpontaneous evaporation of brine expoſed to the weather in ſummer in reſervoirs of a given dimenſion, at Aigle in the canton of Berne.[h] Though a mountainous country the climate is here warm enough for the vine and pomegranate. The heat in the middle of ſummer riſes from 140° to 144° in the ſun. To contain the brine a reſervoir was made of the coarſe marble of the country, the joints of which were lined with aſphaltum to prevent leakage. This reſervoir was covered with a light moveable roof, which was put up only in rainy weather. Another reſervoir was alſo made of wood, but it is found that the ſoundeſt timber will not entirely ſtand the preſſure of a column of ſalt water except of a few inches, for after a time the brine oozes through, and covers the outſide with a ſtalactitical ſaline cruſt. The particulars of theſe experiments which were carried on with great attention for ſeveral years, need not be related at large, as they are calculated for a climate very different from ours. In general it may be obſerved that the utmoſt exhalation for a ſingle day in ſummer, was found to be 3 lines or ¼ of an inch. Scarcely any thing exhaled in the winter months. From October to February (4 months) the entire exhalation was only 10 lines. In March, the average exhalation for the whole month was 15 lines; in April 35; in May 48; in June 44; in July 47; in Auguſt 35; in September 25, and in October 15. The mean exhalation from March to October therefore, was 261 lines, or 21¾ inches. Theſe numbers however do not give accurately the relative exhaling power in the different months, for the brine as it becomes more and more condenſed, parts with its water with much more difficulty, and the above experiments only give the continued loſs by exhalation of the ſame brine for many months conſecutively.

The quantity of ſalt yielded by ſpontaneous exhalation is nearly equal to that produced in experiments in the ſmall way on a few pounds of brine, which is far from being the caſe in actual manufacture. The ſalt obtained thus gradually is large-grained, of an opake white, very hard and ſomewhat inclined to dampneſs, and not very readily ſoluble. The common ſalt on the other hand is ſemi-tranſparent, ſofter, and more readily ſoluble.

During the evaporation of brine in a boiling heat the vapour that riſes is ſenſibly ſaline, and gives a ſaltiſh impregnation to wood and other porous matter which it meets with. It has been aſſerted that part of the acid alſo is ſeparated in this heat and volatilized, leaving the ſalt therefore with a greater proportion of alkali, and to this has been attributed the inferior power of the ſmall-grained ſalt in preſerving proviſions.

Though the inferiority be undoubted it does not appear that any very accurate experiments have been made on the relative quantities of acid in the large and ſmall-grained ſalt, this hypotheſis therefore is altogether doubtful. Neither does the large-grained ſalt owe its ſuperior ſtrength to any ſuperior purity or freedom from the deliqueſcent earthy muriats, for the fine London baſket ſalt is ſomewhat purer than the beſt Portugal bay ſalt, though the quantity of earthy matter in each is ſcarcely notable. On the whole it is more probable that the hardneſs of texture and ſlow ſolubility in water of bay or fiſhing ſalt (which it owes to the ſlowneſs of cryſtallization) is the chief cauſe of its ſuperior efficacy.

Methods of procuring Soda by decompoſition of Common Salt.

Muriat of ſoda being the moſt abundant of the neutral ſalts, and its alkaline baſe bearing for the moſt part a higher price in the market than potaſh, has been ſubjected to a vaſt variety of proceſſes both on a ſmall and large ſcale, with more or leſs perfect ſucceſs, for the purpoſe of effecting its decompoſition, ſo as to obtain the alkali ſeparate, or at leaſt only combined with carbonic acid. Theſe different methods naturally divide themſelves into two claſſes, the firſt containing thoſe that aim at the immediate extraction of the alkali, and the ſecond thoſe that ſeek the ſame end, but by more complex means. Under the firſt claſs will be deſcribed the decompoſition of ſalt by lime, by iron, by oxyd of lead, and by potaſh; under the ſecond claſs will be mentioned the different methods of decompoſing ſalt after it has been previouſly converted into ſulphat of ſoda.

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[h] Mem de l'Acad. for 1764.

It was Scheele[a] who firſt diſcovered in contradiction to the eſtabliſhed laws of chemical affinity, that muriat of ſoda might be decompoſed by means either of iron or quick-lime in an atmoſphere conſiderably charged with carbonic acid. Thus if a plate of iron is dipped in a ſaturated ſolution of common ſalt, and then hung up in a cellar, a decompoſition of the ſalt will be found to have taken place in the courſe of a few days; the ſurface of the iron will be ſtudded with drops of a yellow liquor, conſiſting for the moſt part of muriat of iron, while the ſoda liberated from the muriatic and combined with the carbonic acid, will have aſſumed the appearance of ſmall ſpicular cryſtals riſing from the ſurface of thoſe parts of the plate that are not occupied by the muriated iron. So in like manner if quick-lime be formed into a paſte with a ſtrong brine of common ſalt, and the mixture be placed in a cellar for ſome days, the ſurface of the lime will be covered with a light down of ſlender cryſtals of carbonated ſoda; theſe being removed they will be ſucceeded by a ſecond ſimilar effloreſcence, and the ſecond by a third. The decompoſition in both theſe caſes is attributed by Scheele, and apparently with great reaſon, to the effloreſcent quality of carbonat of ſoda, which readily diſpoſes it to riſe from the ſurface where it is generated in ſpicular cryſtals, and thus ſeparate itſelf from the muriat of iron or lime by which it would be again decompoſed. This explanation of the fact derives additional force from the circumſtance that muriat of potaſh is not decompoſable either by lime or iron, probably becauſe carbonat of potaſh, not being an effloreſcent ſalt, is unable to ſeparate itſelf from the reſt of the maſs. Vauquelin[b] ſeems diſpoſed to attribute the decompoſition of common ſalt by lime, to the formation of an inſoluble muriat of lime with exceſs of baſe, but this appears to be diſproved by an obſervation of Scheele, that if the reſiduum after the effloreſcent ſalt has been collected be lixiviated, and the exceſs of lime in the ſolution be got rid of by means of carbonic acid, the remaining clear liquor will furniſh an abundant precipitate of carbonated lime on the addition of the effloreſced carbonat of ſoda, thus ſhewing that the ſolution contains muriat of lime in its ordinary ſtate. Berthollet has ſhewn that even carbonat of lime, when in great exceſs, is capable of decompoſing muriat of ſoda, more eſpecially if ſtraws or any other ſimilar ſubſtances are ſtuck upright into the maſs, to aſſiſt the effloreſcent power of the ſoda, by offering a ſupport on which it may concrete and eſcape the re-action of the muriated lime: this method is indeed conſiderably leſs expeditious than that diſcovered by Scheele, yet it ſeems to be the very mode employed by Nature at the Natron lakes of Egypt, as Berthollet has ſhewn in a very intereſting report on this ſubject.[c]

Of the three modes of decompoſing muriat of ſoda mentioned above, that by means of quick-lime is the only one that has been attempted on a large ſcale, but though ſuperintended by ſo able a chemiſt as Morveau[d] it does not appear to have been attended with ſufficient advantage to counterbalance the expence of time and fuel. The proceſs employed differed in no reſpect from that of Scheele, except that the mixture after it had ceaſed to yield any more ſoda was re-calcined and again treated with a ſolution of common ſalt. It has been propoſed as an improvement of this proceſs, to mix with the lime and ſalt a ſufficient quantity of clean ſand to convert it into mortar, and then to line cellars or other excavations with it, in order to expoſe a larger ſurface to the action of the air. There is no doubt that the yield of carbonated ſoda would thus be greatly augmented, and it is not improbable where natural or artificial excavations could be conveniently obtained, that the increaſed product would more than equal the additional expence.

The poſſibility of decompoſing common ſalt by means of litharge or any other of the oxyds of lead, was firſt aſcertained by Mr. Turner, who obtained a patent for the diſcovery in the year 1780. His proceſs is the following:[e] To ten parts of any of the oxyds of lead add five parts of muriated ſoda, previouſly diſſolved in water; grind the whole together till the litharge becomes almoſt impalpable, and then let the mixture ſtand for twenty-four hours, in which time the lead will appear of a white colour: the maſs, which will have acquired a tolerably ſolid conſiſtence, muſt now be broken down in water and be well waſhed; the liquor will contain the alkali of the ſalt, and the white inſoluble reſidue conſiſts of the litharge combined with muriatic acid. This reſidue after being carefully lixiviated and dried, if expoſed on a muffle or in any other ſuitable way to a calcining heat, acquires a yellow colour, varying in tint according to the temperature; this yellow muriat when ground up with oil and varniſh in the uſual manner, forms a pigment known by the name of *patent yellow*, and very extenſively employed in coach-painting.

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[a] Eſſays, p. 55.

[b] Ann. Chem. xxxi. p 10.

[c] Mem. de l'Inſtit. de Cairo.

[d] Ann. Chim. xix p. 102.

[e] Repertory xii. p. 157.

A ſolution of muriated lead is readily decompoſable by ſoda, either cauſtic or carbonated; the explanation therefore of this ſeeming anomaly on which Mr. Turner's patent was founded, became an important chemical problem, and has exercifed the abilities of Kirwan, Haſſenfratz, Berthollet, Vauquelin, and others. By the experiments of the laſt of theſe able chemiſts the difficulties have been cleared up, and the apparent contradiction has been reconciled to the general laws of chemical affinities.[f] He mixed together, by grinding in a mortar, ſeven parts of litharge and one of muriated ſoda, adding as much water as brought the whole to the conſiſtence of thin paſte; it was then ſtirred for ſeveral hours to facilitate the mutual action of the ingredients. By degrees the colour of the litharge became paler, its volume increaſed very conſiderably, and ſeveral additions of water were required to prevent it from forming a ſolid maſs: at the end of four days the chemical change appeared to be compleat, the litharge having acquired a white colour, the mixture was accordingly diluted with ſeven or eight parts of water and filtered. The clear liquor had an alkaline flavour, and when reduced by evaporation to $\frac{1}{10}$ of its bulk, afforded cryſtals of carbonated ſoda mixed with a little muriat of lead, and the common ſalt was intirely decompoſed. The reſidue on the filter when well waſhed and dried, was of a dirty yellow colour, and exceeded in weight the litharge employed by about $\frac{1}{8}$; by a gentle calcining heat its colour was changed to a fine lemon yellow, and its weight was diminiſhed by about 2.5 *per cent.* In pure water even when boiling it is ſcarcely ſoluble; but by digeſtion with cauſtic ſoda a conſiderable portion was taken up, and the reſidue aſſumed a dirty white colour, and was changed from a pulverulent conſiſtence to that of needle-form cryſtals. The ſoda ſolution was but little different in taſte from the pure alkali, but gave a very abundant black precipitate with hydroſulphuret of ſoda, a white precipitate with muriatic acid, and alſo with nitric acid, but this laſt was reſoluble in an exceſs of acid. If the yellow reſidue was treated with dilute nitric acid inſtead of ſoda, there remained an inſoluble portion of a white colour and cryſtalline texture, and the nitrous ſolution depoſited by gentle evaporation cryſtals of nitrat and muriat of lead.

From theſe facts it appears that litharge by the decompoſition of common ſalt, is converted into a ſub-muriat, or muriat with exceſs of baſe, and therefore differing very materially from the common muriat; that this ſalt though ſoluble in cauſtic ſoda is not decompoſable by it; and that the efficient cauſe of the decompoſition of common ſalt by litharge is the property of muriated lead to combine with an exceſs of baſe, by which the affinity of the acid for the alkali is counteracted; that the yellow colour which this ſub-muriat acquires by being heated, is occaſioned by the exceſs of baſe, ſince the common muriat exhibits no ſuch character; that to this exceſs is alſo owing the inſolubility of this ſubſtance in water; and finally that by the addition of nitric acid the ſub-muriat is decompoſed, being itſelf converted into muriat, and yielding its exceſs of oxyd to the nitric acid.

In confirmation of the opinion that the oxyd of lead decompoſes common ſalt only in conſequence of its being converted into a ſub-muriat, it may further be remarked, that the white precipitate depoſited by the action of cauſtic ſoda on the ſoluble muriat is not a ſimple oxyd as has been generally ſuppoſed, but a ſub-muriat, exactly ſimilar to that which we have been deſcribing.

It has been ſuppoſed by ſome chemiſts that the carbonic acid which litharge and moſt of the other oxyds of lead contain, has a conſiderable ſhare in effecting the decompoſition of muriat of ſoda, this however has been denied by other chemiſts, and particularly by Vauquelin, who affirms that carbonat of lead and muriat of ſoda have abſolutely no action whatever on each other. This being the caſe it follows that litharge, minium, &c. are the worſe calculated for decompoſing common ſalt in exact proportion to the carbonic acid which they contain: hence ariſes the propriety of mixing quick-lime with the litharge, in order to abſorb its carbonic acid, and thus expedite its action. By availing himſelf of this addition M. Curadeau[g] found that 30 parts of litharge and 4 of quick-lime, were able to effect a total decompoſition of 10 parts of muriated ſoda. But even with this improvement and with every attention to economy, it does not appear that this method of ſeparating the ſoda from ſea-ſalt can be attended with much profit on a large ſcale: the demand for the yellow ſub-muriat is very limited, and the white ſub-muriat although its colour is very good, is not poſſeſſed of ſolidity enough when ground up with oil to be employed as a ſubſtitute for common white lead: it would therefore be neceſſary in a large eſtabliſhment to reduce moſt of the ſub-muriat to the ſtate of metallic lead, at a conſiderable expence of fuel and labour, and of loſs by volatilization, &c. and then by a ſecond proceſs to re-calcine the lead before it could be brought again into ſervice.

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[f] Ann. Chem. xxxi. p. 1.

[g] Ann. Chem. xiv. p. 15.

Another method propoſed for the decompoſition of common ſalt, and which ſeems to have attracted conſiderable notice among the German chemiſts, is founded on the ſuperior affinity of potaſh over ſoda, for muriatic acid; if therefore to a ſolution of common ſalt there be added a ſufficient quantity of potaſh, either cauſtic or carbonated, an exchange of baſes will take place, and the fluid will yield by evaporation and cryſtallization carbonated ſoda and muriated potaſh. But this mode of proceeding is by no means ſo eaſy and ſimple in practice as in theory, as may be ſeen in a memoir on the ſubject by Weſtrumb,[h] from which the following account is extracted.

Diſſolve 20lbs of common ſalt in 30 quarts of water, and add to the ſolution 25 lbs of purified potaſh or pearlaſh, then evaporate the liquor till three or four ſtrong pellicles have formed in ſucceſſion on its ſurface, each in turn being broken down by any convenient inſtrument: the liquor being now transferred into another veſſel, is to be kept at the temperature of about 60° Fahr. as long as it depoſits any cryſtals. The ſalt thus formed is a mixture of muriat and ſulphat of potaſh (the latter pre-exiſting in the potaſh) which may be ſeparated from the liquor by paſſing it through a filter made of flannel. The filtered ſolution after ſtanding about an hour longer, will depoſit more muriat of potaſh, mixed however with carbonated ſoda. Theſe ſalts being removed and the reſidual liquor being placed in a cellar or any other place ſufficiently cold, will yield a copious depoſit of cryſtallized carbonated ſoda. The ſupernatant liquor being again treated as at firſt, affords a ſecond crop of muriated potaſh, and afterwards by refrigeration, of carbonated ſoda: and theſe two proceſſes are repeated in ſucceſſion till the mother water refuſes to yield any more ſalt. The different parcels of muriated potaſh are now to be mixed, and diſſolved in boiling water, which is afterwards to be evaporated to one half, during which a conſiderable depoſit of muriated potaſh will take place: the ſupernatant liquor being transferred to another veſſel and expoſed to the cold will depoſit a conſiderable part of the carbonated ſoda which it contains; a ſecond evaporation and cooling will ſeparate a further portion of the ſame, after which it is not worth while to purſue the proceſs any further. The carbonated alkali thus obtained is to be mixed with the reſt and the whole diſſolved in an equal weight of water; the ſolution by cooling depoſits a large quantity of carbonated ſoda in a ſtate of conſiderable purity; the remaining liquor being evaporated will generally yield more or leſs of muriated potaſh while it cools, and then by expoſure to a low temperature a ſecond crop of carbonated ſoda may be obtained: by again repeating on the remainder the proceſſes of evaporation and cooling a ſecond crop of muriated potaſh and a third of carbonated ſoda are procured; but this laſt being conſiderably leſs pure than the two preceding crops of carbonated alkali, is to be kept apart.

All the preceding operations are compleated in 12 or 14 days, and the average produce is 20 lbs of pure cryſtallized and 2½ lbs of impure cryſtallized carbonat of ſoda. The amount of muriat of potaſh is not mentioned by Mr. Weſtrumb. If the above is a true repreſentation of the mode of carrying on the decompoſition, and of the amount of produce obtained (which there ſeems no reaſonable cauſe to doubt) it is obvious that it can only be performed with profit in countries far remote from communication with the ſea, where potaſh and common ſalt are very abundant and labour extremely cheap: it is alſo manifeſt that when carried on in the large way the ſeparation of the ſoda from the other ingredients muſt be even more difficult than is repreſented by M. Weſtrumb, on account of the great accumulation of mother water; and after all that can be done by cryſtallization and evaporation, by far the greater part of the ſoda will be loſt. Common ſalt contains 53 *per cent.* of alkali; and carbonated ſoda in cryſtals contains 22 *per cent.* of the ſame, whence it appears from Mr. Weſtrumb's own proportions that no more than 21½ lbs of carbonated ſoda are obtained from materials that contain 48 lbs.

But the moſt eligible methods of obtaining the alkali from common ſalt are thoſe by which it is firſt converted into Glauber's ſalt previouſly to the extraction of the ſoda. It will be proper therefore firſt to conſider the various ſources from which ſulphat of ſoda may be obtained by the decompoſition of ſea ſalt.

It is produced in the moſt economical manner as a reſidue in various chemical manufactures, ſuch as the preparation of ſal ammoniac, of muriatic acid, and of oxymuriatic acid for the bleacheries. In ſituations however where theſe reſidues are not to be obtained, it muſt be prepared by the direct decompoſition of muriated ſoda: the two cheapeſt methods of effecting this appear to be by means of gypſum and of iron pyrites.

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[h] Journ. de Phyſ. xxxv. p. 295.

The firſt of theſe is carried on in the following manner. Take any quantity of calcined gypſum and ¼ of its weight of common ſalt; mix them accurately by grinding, or in any other convenient way, then add to the powder a ſufficient quantity of water and make it up into balls three or four inches in diameter. When theſe balls are dry, let them be calcined for five or ſix hours in a reverberatory furnace, then break them down into pieces no larger than a hazle nut, and lixiviate them with cold or warm water: the liquor when boiled to a pellicle affords by cooling cryſtals of Glauber's ſalt.

[1]The ſecond method, or that by means of pyrites is thus accompliſhed. Take 100 lbs. of common pyrites and reduce it to fine powder, then add 40 lbs. of common ſalt; mix the two ingredients well together and expoſe the maſs for 60 hours to a roaſting temperature; a copious diſengagement of muriatic and ſulphureous acids will take place, and the maſs will ſtill continue pulverulent, but of a browniſh red colour, and reduced in weight to 107½ lbs.

Being now lixiviated and the liquor boiled down to a proper conſiſtence, there will be depoſited about 45 lbs. of cryſtallized ſulphat of ſoda, and the mother water evaporated to dryneſs will leave between 8 and 9 lbs. of a ſaline maſs conſiſting of ſulphat of ſoda, muriat of iron, and a little undecompoſed common ſalt. The inſoluble reſidue conſiſts of ſulphuret of iron with exceſs of oxyd, weighing 67½ lbs. in a highly favourable ſtate for vitriolization.

A conſiderably greater quantity however of ſalt can be decompoſed by a given weight of pyrites if there be added to the mixture either charcoal, pitcoal, or peat, but eſpecially the latter. For this purpoſe 100 lbs. of pulverized pyrites and 300 lbs. of dried peat being well mixed together, 65 lbs. of ſalt diſſolved in water are to be added, and the whole maſs after being carefully tempered is to be made up into balls. Theſe balls when dry are to be placed in a reverberatory furnace with a little fuel juſt to kindle them, after which they will burn of themſelves; the combuſtion is to be kept up as gentle as poſſible till the incineration is compleat, and then the aſhes being lixiviated and the liquor boiled down in the uſual manner, there will be procured 70 lbs. of cryſtallized ſulphat of ſoda, and 17 lbs. of dry ſalt, conſiſting of muriat of iron and ſulphat of ſoda, from evaporating the mother water.

The ſulphat of ſoda whether obtained from the ſources above pointed out or from any other, may be decompoſed ſo as to afford its alkali in a ſeparate ſtate by either of the two following methods, the ſucceſs of which has been proved by experiments on a very large ſcale.

1. *Decompoſition of Glauber's ſalt by the combined action of chalk and charcoal.*

Take 1000 lbs. of calcined Glauber's ſalt and 550 lbs. of charcoal, and mix the two ingredients accurately together by grinding; when the mixture appears compleat add by degrees 1000 lbs. of waſhed chalk, and continue the grinding till this alſo is mixed with the other materials. Now let a reverberatory furnace be lighted, and as ſoon as it is red hot let it be charged with 4 or 500 lbs. (more or leſs according to the ſize of the furnace) of the above mixture, and cloſe the door. During the firſt part of the proceſs, while the materials are yet pulverulent the flame muſt be kept as gentle as poſſible leſt it ſhould carry part of the powder up the chimney; but as ſoon as the matter begins to clot the flame may be increaſed. At this time the maſs muſt be carefully worked about with an iron rake in order to expoſe freſh ſurfaces to the action of the flame. When the whole has acquired a paſty conſiſtence jets of inflamed ſulphuretted hydrogen will be perceived to iſſue from every part, accompanied by a moderate but very perceptible exploſion and efferveſcence; and during the whole of this ſtage of the proceſs the rake muſt be uſed very vigorouſly in order to expedite the diſengagement of the gas. When the jets of flame ceaſe, and the matter becomes nearly fluid the rake may be withdrawn, and a bar of cold iron is to be introduced from time to time in order to judge of the progreſs of the operation by the ſample that adheres to the end of it: if this cracks as it grows cold and preſents an uniform granular texture the heat has been continued long enough, and the matter muſt then be ſpeedily withdrawn leſt it ſhould be fritted by the further action of the fire. The flame being accordingly turned off for a few minutes, the maſs returns to a paſty conſiſtence and is withdrawn from the furnace by means of the rake. As ſoon as it becomes ſolid by cooling, it is to be broken into moderate ſized pieces and kept for ſome days in a damp cellar, where it imbibes a conſiderable quantity of water and carbonic acid, falls to powder and at the ſame time parts almoſt entirely with the ſulphuretted hydrogen to which its hepatic ſmell and flavour when recent are owing. It may now be brought to market, without any further preparation, or the alkaline part may be extracted and ſold ſeparately.

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[1] Pelletier Mem. de Chem. II. p. 208, or An de Chem. xix.

In order to ſeparate the alkaline from the earthy part lixiviation with cold water muſt be had recourſe to: the clear liquor by evaporation to a pellicle and ſubſequent cooling, depoſits cryſtals of carbonated ſoda, and the mother water, conſiſting chiefly of ſemicauſtic ſoda, muſt be boiled down to dryneſs and afterwards calcined till it is as white as pearlaſh, in which ſtate it is well fitted for the glaſs makers.

500 lbs. of raw materials treated as above deſcribed afford 276 lbs. of rough ſoda, of which 100 lbs. yield by lixiviation 37 lbs. 8 oz. of cryſtallized carbonat, and 23 lbs. 2 oz. of dry ſemicauſtic ſoda, with a ſmall admixture of ſulphuret of lime and of other ſalts accidentally contained in the original ſulphat.

2. *Decompoſition of Glauber's ſalt by means of iron and charcoal.*

	lbs.	
Take	200	Calcined Glauber's ſalt
	40	Powdered charcoal
	65	Clippings of iron plate or old iron
	22	Charcoal in the ſtate of ſmall coal
	327 lbs.	

Having mixed the ſulphat of ſoda with the powdered charcoal, let it be introduced into the reverberatory furnace and treated for the firſt hour exactly as deſcribed in the foregoing proceſs: then bring the mixture to compleat fuſion and add 40 lbs. of the clippings, ſtirring the materials well at the ſame time with an iron rake in order to mix them more compleatly. In a ſhort time after, the matter which was at firſt quite fluid will become paſty, accompanied with much foaming and boiling till the clippings are diſſolved: as ſoon as this takes place, 16 lbs. of ſmall coal muſt be ſtirred in, which will immediately excite the diſengagement of ſulphuretted hydrogen mentioned in the former proceſs. When this appearance begins to ſlacken, the remaining 25 lbs. of clippings and 6 lbs of ſmall coal are to be added in ſucceſſion, and the ſtirring is to be diligently continued till the jets of inflamed gas almoſt ceaſe: when this happens, the matter ſtill fluid is to be run into moulds of ſand where it ſolidifies.

The rough ſoda thus prepared weighs 215 lbs. is of a blackiſh brown colour which becomes ſtill darker by the contact of the air: when broken it has a kind of metallic luſtre and a cloſe ſtriated texture. To the taſte it is cauſtic and hepatic: by expoſure to a moiſt atmoſphere it becomes covered with a yellow efflorescence, and quickly falls to powder with a conſiderable diſengagement of heat and ſulphuretted hydrogen; at the ſame time it abſorbs carbonic acid and water ſo as to increaſe in weight by an expoſure of about 20 days in the proportion of 5 to 8.

From the 215 lbs of rough ſoda thus obtained and increaſed by abſorption of air and moiſture to 344 lbs. may be obtained by lixiviation and cryſtallization 152 lbs. of carbonated ſoda, and the uncryſtallizable mother water will afford by evaporation about 47 lbs. of ſemicauſtic ſoda mixed with a little charcoal, ſulphuret of iron and other impurities. The inſoluble reſidue weighs about 185 lbs. and is ſulphuret of iron with a little charcoal in a ſtate highly favourable for vitriolization.

MURIAT OF AMMONIA. See SAL AMMONIAC.

MURIAT OF LIME.

This earthy ſalt was firſt known in chemical manufacture as the reſidue from the diſtillation of carbonat of ammonia by chalk and muriat of ammonia. It is alſo found native frequently, but in ſmall quantities, in a great variety of ſaline ſprings, but never entering into any ſolid mineral.

To procure it pure any quantity of pure chalk or white marble is to be diſſolved in pure muriatic acid to ſaturation, and the clear fluid evaporated to a thick ſyrupy conſiſtence, when by cooling it will congeal into a yellowiſh tranſparent ſaline maſs, of a ſtriated texture. This ſalt may alſo be procured in regular cryſtals in the form of ſix ſided priſms terminated by ſix-ſided pyramids, but it is not eaſy to cryſtallize this ſalt. Pelletier ſucceeded by expoſing a concentrated ſolution to very gradual evaporation in a warm and dry air. Beaumé finds the ſame cryſtallization when the ſolution is long kept in bottles.

This ſalt is one of the moſt deliqueſcent of all the known ſalts, ſo that the cryſtals kept expoſed to the air, or even in a bottle but ſlightly ſtopped, ſoon reſolve into a denſe yellowiſh liquid reſembling oil in appearance, and called by the older chemiſts *oil of lime*. This may be again brought to the ſame cryſtallized maſs by evaporation and cooling.

Muriat of lime has no ſmell. The yellowiſh colour which it has is probably owing to the ſmall quantity of iron which is contained in almoſt every calcareous earth, and alſo in common muriatic acid. The taſte is acrid, bitter, and nauſeous.

The ſolubility of this ſalt is indefinite in a warm temperature, for it readily melts in its water of cryſtallization when heated. Cold water will diſſolve twice its weight, and hence the ſolution muſt be extremely concentrated before the ſalt will ſeparate in a ſolid form by cooling. If a ſolution ſo far concentrated as to cryſtallize by cooling be poured hot into a bottle and immediately corked, it will remain fluid for ſome time when cold, if quite at reſt, and then when the cork is drawn and the bottle ſhaken, the whole will ſolidify in a few ſeconds with the evolution of ſo much heat that the bottle cannot be held in the hand. This experiment however does not always ſucceed, nor with ſo much certainty as with Glauber's ſalt.

Muriat of lime heated *per ſe* firſt liquefies and as it dries puffs up extremely and turns to a white ſaline maſs ſtill deliqueſcent. If the heat be continued it parts with a portion of its acid but not the whole. Beaumé has the following analytical experiment on the ſubject. Four ounces of muriat of lime heated for three hours in a fire gradually raiſed to redneſs, gave an ounce of good colourleſs muriatic acid, and the maſs remaining in the retort was white, ſpongy, and ſaline. Three ounces of cold water were added which immediately acquired a boiling heat, and on adding more water and filtering, a clear ſolution of muriat of lime was obtained, and a quantity of inſoluble earth left behind. This liquor evaporated to dryneſs and diſtilled in a very ſtrong heat till the retort was ſoftened, gave nothing more than a very ſlightly acidulous water. Muriat of lime when heated in an open crucible parts with more of its acid, but never with the whole. The reſidue from the diſtillation of volatile alkali is phoſphoreſcent when heated. It is compoſed of muriat of lime with exceſs of lime, and probably alſo of ſome undecompoſed chalk. It forms *Homberg's phoſphorus*.

Muriat of lime is very ſoluble in alcohol. When rectified, alcohol diſſolves its own weight.

Pelletier relates a curious and unaccountable phenomenon. If carbonic acid is paſſed through a ſolution of muriat of lime the whole preſently changes into a ſubſtance ſo ſolid as to require a ſtrong ſtroke of the hammer to break it.

The ſulphuric acid decompoſes this ſalt, and owing to the ſparing ſolubility of the ſulphat of lime and the high ſolubility of the muriat, if ſulphuric acid is poured into a concentrated ſolution of the latter ſalt, the whole immediately turns to a white ſolid maſs of calcareous ſulphat.

The compoſition of this ſalt is thus given by Kirwan: fifty parts of pure lime ſaturated with muriatic acid, form 100 of the muriat when heated to redneſs, and 100 parts of muriat in this ſtate therefore contain 50 of lime, 42 of acid, and 8 of water.

This ſalt has ſome not unimportant uſes in chemiſtry. From its great tendency to deliqueſcence, it is valuable in the experiments on gaſes to abſorb the moiſture from them. For the ſame reaſon alcohol is brought to a very high degree of rectification when diſtilled off the dry muriat. The cryſtallized muriat alſo affords the cheapeſt and moſt powerful ſubſtance as a freezing mixture, to produce the moſt intenſe degrees of artificial cold, as mentioned under the article *Freezing*.

MURIAT OF BARYTES.

This ſalt is never found native. It may be prepared by diſſolving either the natural or artificial carbonat of barytes in muriatic acid, or from ſulphuret of barytes and muriatic acid, or from muriat of lime and ſulphat of barytes, all of which methods are deſcribed under the articles *Barytes* and *Carbonat of Barytes*. Muriat of barytes cryſtallizes readily from a hot concentrated ſolution by cooling, or by ſlow evaporation. The cryſtals are large, of an opake white, and generally in octogonal tables truncated at the angles. The taſte is acrid and aſtringent. It is one of the heavieſt ſalts known, and is readily diſtinguiſhable from moſt other ſalts by its external properties.

This ſalt is not deliqueſcent, nor in any way alterable in the air. When heated it loſes its water of cryſtallization, but none of its acid. In a ſtrong fire it melts, but is not in any other way altered. About five parts of cold water diſſolve one part of the cryſtallized ſalt, and boiling water ſomewhat more, but to cryſtallize it readily by cooling, it muſt be conſiderably concentrated by evaporation. It contains 64 of barytes, 20 of acid, and 16 of water of cryſtallization.

Sulphuric acid and every ſoluble ſalt containing it decompoſes muriat of barytes, and forms an inſoluble ſulphat of barytes, and this takes place with ſuch minute quantities as to render the muriat (as well as the other ſoluble ſalts) of barytes a moſt valuable teſt for ſulphuric acid in any form. Nitric acid alſo decompoſes this muriat, and if it is much concentrated a white precipitate of nitrat of barytes falls down, owing to the more ſparing ſolubility of the nitrat in water than of the muriat. But it is diſſolved by adding more water, by which it may be readily diſtinguiſhed from the ſulphat.

Muriat of barytes is uſed as a teſt for ſulphuric acid in chemical experiments. It has alſo been employed in medicine, and like all the other ſoluble barytic ſalts it is a powerful poiſon in large doſes.

Muriat of Strontian.

This ſalt is prepared by diſſolving ſtrontian or its carbonat in muriatic acid. The modes of procuring ſtrontian will be found under the articles *Strontian* and *Carbonat of Strontian*. The ſalt cryſtallizes in long needles, very tender and eaſily broken, the form of which it is not eaſy to determine, but the ſtriking difference in the appearance of muriat of ſtrontian and muriat of barytes will readily enable the chemiſt to diſtinguiſh theſe ſalts, which in other reſpects have many properties in common.

Muriat of ſtrontian is one of the moſt ſoluble of all the known ſalts. A hundred parts of the cryſtallized ſalt required but 75 of water at a moderate temperature, and when heated it diſſolves in its own water of cryſtallization. Alcohol when boiling alſo diſſolves a large quantity, but the greater part is again ſeparated by cooling. The alcoholic ſolution when ſet fire to, burns with a beautiful crimſon flame, which is a very uſeful teſt for ſtrontian. The taſte of the ſalt is cooling at firſt, and afterwards rather acrid, but not auſtere like muriat of barytes, nor bitter. It is not poiſonous. This ſalt is not deliqueſcent. When heated it loſes its water of cryſtallization, but none of its acid. Its component parts according to Vauquelin, are (in the cryſtallized ſtate) 36.4 of ſtrontian; 23.6 of acid; and 40 of water.

It is not applied to any uſe.

Muriat of Magnesia.

Magneſia diſſolves in muriatic acid with great eaſe, forming a bitter nauſeous ſalt which cannot but with extreme difficulty be brought to cryſtallize, but when evaporated nearly to dryneſs becomes a gelatinous, ſhapeleſs, deliqueſcent maſs. It is found abundantly in nature, particularly in ſea-water, to which this owes its bitter nauſeous taſte. It alſo often accompanies common ſalt in the water of inland brine ſprings.

This ſalt is extremely ſoluble, requiring only its own weight of cold water. Boiling water takes up much more, ſo that a hot ſaturated ſolution on cooling coagulates to a gelatinous maſs.

Muriat of magneſia is compleatly decompoſable by heat, the whole of the water of cryſtallization and the muriatic acid flying off and leaving the magneſia pure. In this reſpect it differs from muriat of lime, with which it is often mixed, ſo that it affords an uſeful way in analyſis of ſeparating theſe earths, which has ſometimes been adopted. After calcining the two ſalts, therefore, muriat of lime and pure magneſia are left, which mere ſolution in water will ſeparate. As however muriat of lime is partially decompoſable by the ſame method, it probably would require a repetition of the calcination of the reſidue with freſh acid to ſeparate the earths compleatly.

Muriat of magneſia is readily decompoſable by the fixed alkalies and the alkaline earths. With ammonia, only a part of the earth is ſeparated in a moderate heat, and the remainder unites with the undecompoſed portion into a triple ſalt, the *muriat of magneſia* with *ammonia*, or *ammoniaco magneſian muriat*, which will be preſently mentioned.

The ſaturated carbonat of ammonia (deſcribed under the article *Carbonat of Ammonia*, and made by expoſing the pungent carbonat to the air for ſome hours) produces no precipitate whatever with muriat of magneſia, owing to the exceſs of carbonic acid, till this exceſs is driven off by heat.

Muriat of magneſia is compoſed according to Bergman, of 41 of magneſia, 34 of acid, and 25 of water. It is very ſoluble in alcohol.

Ammoniaco Magnesian Muriat.

This ſalt has been particularly deſcribed by Fourcroy,[a] in a valuable memoir on the triple magneſian ſalts, of which the following are the leading facts: 144 grains of carbonat of magneſia (containing 50 grains of magneſia) were diſſolved in muriatic acid, to which was added 72 grains of liquid ammonia, which cauſed a precipitate which, collected, waſhed and dried, weighed 3¼ grains. Seventy-two grains more of ammonia were added, which gave a further precipitate of 7 grains, though the former ſupernatant liquor was ſtrongly ammoniacal. Another doſe of 144 grains of ammonia gave a further precipitate of 14 grains, after which no further addition of ammonia produced any precipitate. Thus only 24¼ grains, or one-third of the magneſia could be ſeparated by any addition of ammonia, though the quantity of the latter was more than ſufficient to ſaturate the muriatic acid. The remaining liquor yields by ſlow evaporation ſmall polyhedral cryſtals, which have a bitter and ammoniacal taſte, and are the *muriat of magneſia with ammonia*. The compoſition of this ſalt is inferred from the quantity of magneſia ſeparated from the ſolution in the above-mentioned experiment: the 24¼ grains of precipitated magneſia ſaturated with muriatic acid and evaporated ſlowly, ſo as to become a confuſedly cryſtallized maſs, produced 98 grs. of muriated magneſia; hence the 48 grains of magneſia remaining in the ſolution would produce about 196 grs. of muriat, which remained in the triple ſalt. Then as 24½ grs. of magneſia were diſplaced by the ammonia, it is eſtimated that as much ammonia remains in the triple ſalt as is neceſſary to ſaturate as much muriatic acid as will ſaturate 24¼ grains of magneſia. From theſe data M. Fourcroy eſtimates the proportion of this triple ſalt to be 73 *per cent.* of muriat of magneſia, and 27 of muriat of ammonia. It would be eaſy however to ſhew that theſe data are far from ſufficient, and it does not appear that they have been confirmed by analyſis.

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[a] Ann. Chem. tom. 4.

This triple ſalt may alſo be formed by the mixture of concentrated ſolutions of muriated ammonia and muriated magneſia, whereby the ſalt readily ſeparates in ſmall cryſtals. Magneſia agitated with a cold ſolution of muriated ammonia will alſo produce the ſalt.

The ammoniaco-magneſian muriat is readily decompoſable by heat, the muriat of ammonia becomes volatilized, the whole of the muriatic acid flies off, and the magneſia alone is left.

This ſalt is not deliqueſcent as the ſimple muriat of magneſia is: it diſſolves in ſix or ſeven parts of cold water, and in leſs when hot. It is obviouſly leſs ſoluble than either of the muriats of which it is compoſed, ſince it ſeparates in cryſtals when the ſolutions of each are mixed.

Muriat of Alumine.

This ſalt is never found native. It is prepared by boiling muriatic acid on alumine for a conſiderable time, whereby a ſolution is effected which is always acidulous and has a very ſtyptic auſtere taſte. When evaporated to a thick conſiſtence it takes a gelatinous form, but cannot be cryſtallized but with extreme difficulty.

This ſalt is very ſoluble in water. Like the muriat of magneſia, it parts with the whole of its acid by heat, and the alumine remains pure. The ſalt when brought to a gelatinous conſiſtence, is extremely deliqueſcent in the air.

It is not applied to any uſe. According to Richter, 21.8 grains of alumine gave 100 of the muriat, evaporated ſo as to become ſenſibly dry.

Muriat of Zircon, &c.

(*For the other Muriated Earths, ſee theſe Earths reſpectively*).

MURICALCITE. See Bitterspath.

MUSCLE, or Muscular Fibre.

The chemical analyſis of muſcular fibre will be found under the articles Fibrin and Blood.

N

NACRE, or Mother of Pearl.

This term is applied to that beautiful natural white enamel which forms the greater part of the ſubſtance of the oyſter-ſhell, particularly the pearl-oyſter. Its chemical compoſition will be deſcribed under the article Shell.

NADELSTEIN. See Titanium.

NAPTHA. See Bitumen.

NATRON, is a term commonly applied to *Soda*, and particularly its *Carbonat*.

NEPHRITE.[a]

Of this mineral there are the two following ſubſpecies.

1. *Subſp.* Common Nephrite or Jade. *Gemeiner Nephrit*, Wern. *Nephrite commun*, Broch.

Its colour is a ſomewhat dark leek-green verging to blue, or greeniſh or bluiſh white. It occurs maſſive and in detached rounded pieces. The ſmooth external ſurface is glimmering with an oily luſtre; internally it is dull except when mixed with fibres of aſbeſt and ſcales of talc. Its fracture is coarſe ſplintery and ſometimes obſcurely fibrous. Its fragments are indeterminately angular. It is more or leſs tranſlucent; it is hard, difficultly frangible and greaſy to the touch. Sp. gr. of the Oriental 2.97 to 3.04, of the Swiſs 3.31 to 3.38.

Nephrite by expoſure to a moderate heat becomes more brittle and ſemi-tranſparent: it is fuſible before the blowpipe without addition into a white ſemi-tranſparent glaſs.

Of the geological hiſtory of this mineral nothing certain is known. It is found in China and India, in Switzerland, Piedmont and Tyrol.

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[a] Emmerling, Kirwan, Jameſon, Brochant.

It is difficult to ſaw or cut, and even when poliſhed has a muddy appearance; its great toughneſs however enables the artiſt to faſhion it into works of great delicacy. It is much prized by the Hindoos and Chineſe, by whom it is made into taliſmans and idols, and by the Turks, who form it into ſword and dagger handles.

2. *Subſp.* Axeſtone. *Beilſtein*, Wern. *Pierre de Hache*, Broch.

Its colour varies between deep bluiſh and yellowiſh green, and ſometimes paſſes into olive. It occurs in maſs: internally it is ſtrongly gliſtening with ſomewhat of a reſinous luſtre. Its fracture in the great is ſlaty, and in the ſmall, ſplintery. Its fragments are tabular. It is tranſlucent, and in hardneſs and toughneſs approaches nearly to the preceding ſubſpecies.

Its natural ſituation appears to be in beds of argillaceous ſchiſtus.

It occurs in South America, in New Zealand and other iſlands of the Pacific ocean, where it is made by the natives into hatchets, tomahawks and other inſtruments. It is alſo found in Corſica, Switzerland and Saxony.

Nephrite appears to be cloſely connected with whetſtone ſlate and indurated talc.

NEUTRAL SALTS. See SALTS.

NICKEL. *Nikkel*, Germ, *Nikel*, Fr.

Nickel is a yellowiſh white ſemi-malleable metal, difficultly fuſible, attractible by the magnet, ſoluble in nitric acid to which it gives a green colour, and when in the ſtate of oxyd, ſoluble in ammonia, to which it gives a blue colour.

§ 1. *Ores of Nickel.*

Sp. 1. Copper Nickel. *Kupfer Nikkel*, Wern.

Its colour is pale copper red with a yellowiſh or greyiſh tint. It occurs maſſive and diſſeminated, ſometimes though rarely reticular, arboreſcent or botryoidal. It is more or leſs ſhining with a metallic luſtre. Its fracture is imperfectly conchoidal, paſſing into coarſe grained uneven (this latter variety poſſeſſes the leaſt luſtre). Its fragments are indeterminately angular ſharp edged. It ſometimes occurs in granular or curved lamellar diſtinct concretions. Its hardneſs is conſiderable for it gives fire with ſteel, diſengaging at the ſame time a ſtrong arſenical odour. It is brittle, but difficultly frangible. Sp. gr. 6.6.

Before the blowpipe it gives out an arſenical vapour, and then fuſes though not very eaſily into a dark ſcoria mixed with metallic grains. It appears to conſiſt eſſentially of nickel and arſenic, but it alſo contains ſulphur, iron, cobalt, copper, and not unfrequently biſmuth and ſilver.

It occurs in veins both in primitive and ſtratified mountains accompanied by various ores of cobalt and ſilver, and by heavy ſpar, calcareous ſpar, brown ſpar, and quartz.

It is found moſt abundantly at Joachimſthal in Bohemia, Schneeberg, Freyberg and Annaberg in Saxony; and Andreaſberg in the Hartz; it is alſo met with in Cornwall in England, at Allemont in France, in Stiria, in Arragon in Spain, and Kolywan in Siberia.

Sp. 2. Nickel Ochre. *Nikkel Okker*, Wern.

Its uſual colour is apple green, paſſing to graſs-green and greeniſh white; when moiſt the colour is conſiderably deepened. It occurs diſſeminated, and as a ſuperficial covering on copper nickel and the ores of cobalt. It is compoſed of looſe or ſlightly cohering pulverulent particles. It is meagre to the touch and is light.

It is infuſible *per ſe* by the blowpipe, when melted with borax this latter acquires a hyacinthine colour and metallic globules are produced. It is often in part ſoluble in water, but this ariſes from an admixture of ſulphat of nickel, which may thus be ſeparated from the proper ochre.

It is found in the ſame places and ſituations as the preceding ſpecies.

§ 2. *Analysis of Ores.*

Copper nickel though not conſiſting eſſentially of more than two or three ingredients may yet caſually contain a conſiderable variety of other ſubſtances as has been ſhown above. In giving therefore a formula for its analyſis it will be adviſable to conſider it in its moſt compound form. Hence we ſhall ſuppoſe it to contain nickel, arſenic, ſulphur, copper, iron, cobalt, ſilver, and biſmuth, beſides quartz and alumine.

1. The ore being ground to an impalpable powder muſt be digeſted with nitric acid conſiderably diluted, nitrous gas will be given out, and by two or three digeſtions every thing ſoluble will be taken up.

2. The inſoluble portion, conſiſting for the moſt part of ſulphur and ſilex, is to be dried, weighed, and then heated; the *ſulphur* (*a*) will burn off, and its amount may be aſcertained by the difference of weight before and after ignition. The reſidue after being boiled in a little nitrous acid is pure *ſilex* (*b*).

3. Add together both the nitrous ſolutions, nearly ſaturate the liquor with pure ſoda, eva-

porate it conſiderably and then pour the ſolution into cold diſtilled water, by which the oxyd of *biſmuth* (*c*) will be precipitated.

4. To the filtered ſolution add muriat of ſoda drop by drop as long as any precipitate falls down; this is muriat of *ſilver* (*d*).

5. Now evaporate the ſolution nearly to dryneſs, and boil it with ſtrong nitric acid as long as any nitrous gas is given out: during the proceſs red oxyd of *iron* (*e*) will be precipitated.

6. Having removed the oxyd of iron, nearly ſaturate the liquor with ſoda and pour in nitrat of lead as long as any *arſeniat* of lead (*f*) is precipitated, which ſeparate by the filter.

7. The nitrous ſolution being now decompoſed by carbonated ſoda, and the waſhed precipitate digeſted in liquid ammonia, oxyd of *iron* (*g*) mixed with *alumine* (*h*) will be left behind, which may be ſeparated in the uſual way by cauſtic fixed alkali.

8. The ammoniacal ſolution is to be ſlightly ſuperſaturated with nitric acid, and a bar of iron being immerſed in it will ſeparate the *copper* (*i*): after which the liquor is to be decompoſed by carbonated ſoda and the precipitate again digeſted in ammonia, that the iron uſed for ſeparating the copper may be got rid of.

9. The ſolution containing now only nickel and cobalt, is to be treated according to Mr. R. Phillips's [a] method, as follows. Evaporate the liquor till the exceſs of ammonia is driven off, which may be known by the vapour ceaſing to diſcolour moiſt turmeric paper: then *largely* dilute it and pour in pure potaſh or ſoda as long as any precipitation takes place; what falls down is oxyd of *nickel* (*k*).

10. The *cobalt* (*l*) alone remains in ſolution, and may be readily ſeparated by accurately ſaturating the liquor with nitric acid and then adding carbonated ſoda.

The above general mode of proceeding is alſo applicable to the analyſis of nickel ochre, except that it ſhould firſt of all be digeſted in water to diſſolve out any ſulphat of nickel which it may accidentally contain.

Nickel is not applied to any uſe, and therefore no attempt has been made in the large way to reduce its ores. The moſt ſatisfactory method of performing this in the laboratory on ſmall quantities is the following.

a Diſſolve the ore in dilute nitric or nitro-muriatic acid, and then ſtir into the clear ſolution a quantity of finely pulverized charcoal about equal in weight to the ore diſſolved: evaporate the mixture to dryneſs and put it into a bellying cylindrical crucible with the mouth looſely cloſed with a bit of charcoal or an earthen-ware ſtopper. Place the crucible in a wind furnace and give it a full red heat as long as any arſenical vapours are diſengaged: if this is carefully performed nearly the whole of the arſenic will be got rid of in a quarter of an hour or twenty minutes, far more effectually than by ſeveral hours roaſting in the uſual method. Now empty the contents of the crucible upon an earthen teſt, and by a gentle red heat with acceſs of air burn off all the remaining charcoal.

b Transfer the contents of the teſt to a flaſk, and digeſt them with dilute nitric acid as long as any thing is taken up. Then boil the filtered ſolution with a little more acid in order to acidify any arſenic that may yet remain: this being done, ſaturate the liquor with ſoda and add nitrat of lead till it ceaſes to give a precipitate.

c Having ſeparated the arſeniat of lead, add to the clear liquor a little muriatic acid and boil it with a bar of zinc: the ſupernatant deep green liquor will now contain only the oxyds of zinc, cobalt and nickel.

d Decompoſe the ſolution by a carbonated alkali and digeſt the waſhed precipitate in ammonia, by which the zinc will be left behind; and then ſeparate the oxyd of nickel according to Mr. Phillips's method already deſcribed.

e Mix the oxyd of nickel with glaſs of borax and expoſe it in a crucible with a little carbonaceous matter to the higheſt heat of a powerful furnace; a reguline button will thus be produced which is pure nickel.

§ 3. *Phyſical and Chemical properties of Nickel.*

The colour of nickel is a dull yellowiſh white: its fracture is foliated; it is brittle, yet not ſo much ſo as to prevent it from undergoing a ſlight extenſion under the hammer. Its ſp. gr. is = 8.51. It is ſtrongly attracted by the magnet.

Theſe are the characters of the pure regulus as obtained by Mr. Phillips according to his proceſs, the efficacy of which there ſeems no reaſon to ſuſpect. M. Richter however has recently publiſhed a memoir on this metal, [b] in which he claims for it the rank of a noble one, and the characters of which according to him are the following. Its colour is between ſilver and tin white: it is not oxydable by expoſure to the atmoſphere: it is malleable either hot or cold, and by laminating may be reduced into leaves no thicker than $\frac{1}{10}$ of an inch. Its ſp. gr.

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[a] Phil. Mag. xvi. p. 312.

[b] Van Mons Journ. de Chim. vol. vi. or Phil. Mag. xxiii. p. 137.

when fuſed is = 8.279, and when hammered = 8.666. It requires for its fuſion a heat fully equal to that for the fuſion of manganeſe. It is very difficultly oxydable even at a white heat: it is not only attractible by the magnet but is capable of acquiring magnetic polarity. Some of the reguli of this metal obtained by Bergman alſo exhibited nearly the ſame properties, but from the mode of reduction purſued in both caſes it appears almoſt certain that Richter's pure regulus is in fact an alloy of this metal with iron.

Pure nickel is perhaps capable of two ſtates of oxydation: by long expoſure to an intenſe heat with acceſs of air it is converted to a dark brown oxyd which is ſtill magnetical:[c] on the other hand the colour of all its ſalts is green and the precipitate thrown down by decompoſing them with alkali is alſo green, hence it may be concluded that the perfect oxyd of nickel is green, unleſs this colour as in the caſe of the green oxyds of copper be owing to a combination with water. The green oxyd of nickel by moderate ignition becomes aſh-grey with a ſlight tinge of blue or green, and in this ſtate, according to Klaproth[d], is compoſed of 66 of metal and 34 of oxygen. By further ignition it becomes of a blackiſh grey, and contains, according to Richter, 78 of metal and 22 of oxygen. Both the oxyds of nickel by ſtrong ignition in cloſe veſſels even without the contact of any inflammable body are reduced to the metallic ſtate.

Sulphuric acid, eſpecially when heated, diſſolves either nickel or its oxyd; and by evaporation to dryneſs, in order to drive off the ſuperfluous acid, leaves behind a ſaline maſs ſoluble in water and from which by evaporation may be obtained rhomboidal octohedrons truncated at their baſes of ſulphat of nickel. The colour of this ſalt is a bright emerald green, which by moderate ignition to drive off the water of cryſtallization becomes of a greeniſh white.

Nitric acid by the aſſiſtance of heat acts vigorouſly on metallic nickel or its oxyds, and forms with it a graſs green ſolution from which are obtained by evaporation rhomboidal cryſtals: theſe on expoſure to the air at firſt deliquate, but by long expoſure to a warm atmoſphere loſe the greater part of their acid and crumble to a greeniſh white powder.

Muriatic acid ſcarcely acts on reguline nickel but diſſolves its oxyd without difficulty; the evaporated ſolution depoſits irregular cryſtals at firſt deliqueſcent and afterwards effloreſcent like thoſe of nitrated nickel.

Solutions of all the preceding ſalts are decompoſed by the alkaline hydroſulphurets, with which they form black precipitates; but ſulphuretted hydrogen has no apparent effect upon them. Pruſſiat of potaſh throws down a bright ſea-green precipitate; of which, according to Bergman, 250 parts contain 100 of metallic nickel: theſe proportions however differ materially from thoſe given by Klaproth, according to whom 100 grains of reguline nickel after ſolution in ſulphuric acid give a precipitate by pruſſiat of potaſh, which after being ignited ſo as to become entirely attractible by the magnet weighs 300 grains.

Tincture of galls produces no precipitate or even turbidneſs.

The mild alkalies occaſion a light apple-green precipitate of carbonated nickel in the proportion according to Bergman, when carbonated ſoda is employed, of 135 parts for every 100 of regulus: but according to Richter, when carbonated potaſh is employed, of 292 parts for every 100.

The cauſtic fixed alkalies alſo afford a precipitate amounting according to Bergman to 128 parts for every 100 of regulus.

Pure ammonia when added to ſaturation to any of the ſalts of nickel throws down a green precipitate which is again diſſolved by an exceſs of the ſame alkali: the ſolution is now of a beautiful ſky blue colour, and probably contains the acid, the ammonia, and oxyd of nickel combined together into a triple ſalt. The ammoniaco-nitrat of nickel, according to Thenard[e], exhibits the following properties. It depoſits green cryſtals by evaporation; it is decompoſable by ſulphuretted hydrogen and the alkaline ſulphurets: neither acids nor alkalies effect any change in it at the common temperature, but by ebullition with cauſtic potaſh the ammonia is driven off, nitre is formed and oxyd of nickel precipitates. It may alſo be decompoſed by firſt ſaturating the ammonia with an acid and then adding carbonated ſoda.

Not only the ſalts of nickel but the oxyds alſo, and even the regulus, are ſoluble in ammonia, the colour of the fluid thus produced is a dark purple-blue, like the ammoniuret of copper. It is decompoſable with precipitation of the metallic oxyd by either of the cauſtic fixed alkalies, as has been already obſerved in the preceding ſection.

None of the metals are capable of decompoſing the ſalts of nickel: even zinc, although aſſiſted by an exceſs of muriatic acid in the ſolution, and a boiling temperature, has no effect on the ſalt when the nickel is pure: a mud-coloured precipitate indeed is not unfrequently depoſited from the ſolution of common nickel, but this precipitate is for the moſt part arſenic and iron, with which nickel purified in the uſual way always abounds. Hence it is that in proportion to the action of the zinc on this compound ſalt, the green colour of the ſolution becomes more and more pure and bright; and when all the arſenic capable of precipitation by this method has fallen down, no further digeſtion with zinc or any other metal will produce the leaſt effect.

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[c] Bergman, Eſſ. II. p. 243. 272.

[d] Analyt. Eſſ. I. p. 432.

[e] Ann. de Chem. XLII. p. 216.

There are no experiments on the combination of pure nickel with ſulphur or phoſphorus, but as the common regulus unites without difficulty with theſe combuſtibles it is probable that the pure metal will do ſo likewiſe.

The alloys of nickel with the other metals have been but little examined.

When combined with gold in the proportion of three or four grains of the former to an ounce of the latter, neither the colour nor malleability of the maſs materially differs from that of pure gold, but if the proportion of nickel amounts to 20 grains of alloy in the ounce, the reſult is a mixture of a braſs colour, a coarſe grain, and very brittle.[f]

With ſilver it may be combined according to Bergman, in nearly equal proportions, without impairing in any remarkable degree either the colour or ductility of the ſilver.

With copper it forms an alloy of leſs ductility than pure copper, and the magnetic quality of the nickel is diminiſhed though by no means deſtroyed

With tin it forms a white brittle compound.

By mixture with arſenic it forms a brittle and eaſily fuſible maſs, entirely incapable of being acted on by the magnet. If the proportion of arſenic in the compound is conſiderable, it will emit fumes of this metal by expoſure to the blowpipe, and if it be broken to pieces and roaſted at a low red-heat it will be covered with a green arboreſcence of arſenicated oxyd of nickel: by a repetition of alternate roaſtings and reductions with a carbonaceous flux, the arſenic may be ſo far ſeparated as that the alloy will give out no more vapours, nor produce any arboreſcence, after which by repeated ſcorification with nitre, the remaining arſenic may be almoſt entirely got rid of; but this method is neither ſo expeditious or ſatisfactory as that already detailed in the preceding ſection.

Nickel and iron ſeem to unite together in all proportions: the colour of the alloy approaches more to that of ſilver, as the nickel prevails in it; and its ductility and power of magnetiſm appear to be fully equal to that of pure iron. It is remarkable that all the ſpecimens of meteoric iron that have been analyſed, are natural alloys of iron and nickel, of which this latter conſtitutes from 1.5 to 17. *per cent.* Theſe maſſes differ from pure iron in being ſcarcely at all oxydable by expoſure to the weather, it is highly probable therefore that nickel may become a metal of vaſt importance if its power of protecting iron from ruſt be fully eſtabliſhed.

Oxyd of nickel is ſoluble by fuſion in various vitreſcent mixtures, to which it gives different tinges of colour according to the nature of the ſaline ingredient made uſe of as a flux.

A mixture of Pure ſiliceous earth	80 grains,
Carbonated potaſh	60
Oxyd of nickel -	3

affords by fuſion a hard clear violet-blue glaſs.[g]

Siliceous earth -	60
Calcined borax -	60
Oxyd of nickel -	3

yield a glaſs of a clear brown with a tinge of blue, or a hyacinthine colour. A ſimilar effect is produced if either carbonat of ſoda or microcoſmic ſalt be ſubſtituted inſtead of borax. With the latter of theſe fluxes the glaſs while hot is of a deep garnet-red colour.

Siliceous earth - - -	60
Vitrified phoſphoric acid prepared from bones -	60
Oxyd of nickel - - -	3

produce a honey-yellow glaſs, but not quite tranſparent; this defect however is in all probability to be attributed to the phoſphat of lime, which phoſphoric acid ſo prepared almoſt always contains.

NIGRIN. See TITANIUM.

NITROGEN. See AZOT.

NITRIC. NITROUS ACID. *Aqua Fortis of Commerce. Der Salpeterſaure.* Germ.

This moſt important acid is found native in great abundance united with potaſh, in ſome parts of the Eaſt Indies, and it is alſo generated by the putrefaction of animal matters of various kinds, as will be explained under the article

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[f] Hatchett. [g] Klapr. Analyt. Eſſ. I. p. 437.

Nitrat of Potaſh. It is alſo generated in ſeveral chemical proceſſes, and may be produced by the direct union of its two conſtituent parts, *azot*, and *oxygen*, in ſufficient quantity to afford ſatisfactory evidence of its chemical nature; but for the purpoſes of the laboratory and manufacture, it is always prepared from nitre, by the addition of ſome ſubſtance which has a ſtronger affinity with potaſh than the nitric acid has, aſſiſted by diſtillation.

The moſt antient way of procuring this acid and which is ſtill practiſed in many countries (though now ſeldom in England) is by heating ſtrongly a mixture of nitre and clay, or nitre and green vitriol, in earthen or iron retorts, and receiving the acid vapour in proper veſſels. It was ſoon found that alum and ſome other vitriolic ſalts anſwered the purpoſe as well as the vitriol of iron, and laſtly the great improvement was made of employing the vitriolic acid alone, which is the method now univerſally adopted in the laboratory, and chiefly in manufacture, in this country, where this acid is cheap.

The way of procuring the nitrous acid in ſmall quantities, is the following: take a plain glaſs retort of any ſize, put into it any quantity of dry purified nitre in powder (which need not be very fine) dropping it through a paper funnel, that none may lodge in the neck of the retort, and fill it not higher than at moſt two-thirds of the capacity of the body of the veſſel, when the nitre lies light and uncompreſſed. Then pour in (through a glaſs funnel, with a ſtem reaching nearly to the bottom) concentrated ſulphuric acid equal to about half of the weight of the nitre, equally guarding againſt any lodgement of it in the neck of the retort. Then lute on a large tubulated glaſs receiver, and cement the joinings with *fat lute* (the compoſition of which is deſcribed under the article *Cements*). Theſe two are all the veſſels abſolutely required, but the tube of the receiver muſt be only looſely ſtopped, or (what is a better way) it ſhould dip into an empty bottle without luting the joinings. As however towards the end of the proceſs much acid vapour paſſes off which would be loſt in the common way of proceeding, and is partially condenſible by water, one or two bottles of the Woulfe's apparatus, half filled with water, may be added to the receiver, and the abſorption tubes carefully placed, ſo that none of the acidulous water may be ſucked back into the receiver, and mix with the ſtronger acid. The retort is then to be placed in a ſand-bath, and the fire applied gradually.

As ſoon as the nitre and ſulphuric acid mix, faint orange-yellow fumes ariſe, but very ſparingly, till by the aſſiſtance of heat the nitre is compleatly diſſolved in the acid. When this mixture begins to get hot the fumes increaſe, and long wet ſtreaks appear on the neck of the retort, which collect and fall down in drops in the receiver. The heat is now to be increaſed till the mixture boils, and at this point of gentle ebullition the materials are to be kept, during which the drops of acid fall in quick ſucceſſion into the receiver, and the receiver itſelf is lined with the ſame ſtreaks of acid drops. Towards the middle of the diſtillation, when both retort and receiver are filled with the acid vapour, the colour is only a faint orange, ſo that the materials within the retort can be ſeen without much difficulty by looking down (for the hot ſand ſhould be heaped up as high as poſſible, and above the level of the boiling fluid) and even if they cannot be conveniently ſeen the proceſs will be known to go on well by the gentle uniform hiſſing noiſe of the boiling materials, and the moderately rapid fall of condenſed drops in the receiver, which laſt ſhould be kept quite cold with wetted cloths on the outſide if neceſſary. During all this time little, if any, gas or vapour of any kind paſſes beyond the large receiver. At length the vapour in the retort becomes of a higher orange, which ſoon (and rather ſuddenly) deepens into a very dark and nearly opake, orange-red, ſo that the materials can no longer be ſeen; and a little afterwards theſe begin to ſwell conſiderably, and to riſe ſlowly up to the neck of the retort, and if this was at firſt more than half full, the hot half-fluid matter is apt to flow over into the neck, and thence into the receiver, unleſs the heat of the furnace be rapidly checked and the top of the retort cooled by removing the upper part of the ſand. The diſtillation is then to be continued with the heat kept up as high as poſſible without boiling over, and the whole receiver now becomes darkened with red-orange fumes, which find their way on to the connected bottles, where they are chiefly condenſed in the water through which they are forced. At the ſame time however a conſiderable quantity of gas eſcapes, which if examined, is found to be a mixture of azot with a very large proportion of oxygen. When nothing further is given out and the heat is ſufficient nearly to redden the bottom of the retort, the proceſs is concluded.

The products of this diſtillation are:—a quantity of ſtrong heavy nitrous acid, of a bright yellow colour, emitting copious orange-red fumes, of an exceſſively pungent and peculiar ſmell, and of the ſpecific gravity of about 1.5, or half as heavy again as water, if the nitre was thoroughly dried before it was put into the retort, and the ſulphuric acid was very concentrated. The quantity of this acid is on an average about half the weight of the nitre employed. Beſides this the water that receives the nitrous vapour is converted into a weak acid liquor of a blue-green colour.

The ſubſtance remaining in the retort concretes into a beautifully white ſpongy ſaline maſs, conſiſting of ſulphat of potaſh with a ſmall exceſs of ſulphuric acid. This may be diſſolved out of the retort by hot water if the heat has not been ſo intenſe as to melt the glaſs and the ſalt into a kind of opake vitreous maſs.

The proportions of nitre and vitriolic acid here given are two of the former to one of the latter. Even a ſomewhat ſmaller quantity of vitriolic acid will diſengage all the acid of the nitre, but the remaining ſulphat of potaſh is harder, and the heat required for diſtillation is greater, ſo that if it be a preferable object to ſave the retort, not leſs than half the weight of ſulphuric acid ſhould be employed. If this is increaſed to two-thirds, which is ſometimes done, the diſtillation is ſtill eaſier, but the nitric acid contains ſome ſulphuric acid, from which indeed it is ſeldom free till further rectified.

To prepare only a few ounces of the acid, a ſand-heat is not neceſſary, but the retort may be heated by a lamp.

The nitrous acid thus prepared is very ſtrong and fuming, and the leaſt drop ſtains the hands yellow almoſt immediately. When heated to boiling it gives out abundance of red nitrous vapour, and if kept boiling for a quarter or half an hour (which in a narrow-mouthed flaſk can be done without much loſs of acid) it becomes when cold limpid and colourleſs as water, and now no longer fumes. To preſerve it colourleſs it ſhould be kept in a dark place, as the light gradually reſtores the colour.

Thus then there are two forms or ſpecies of this acid, viz. the orange-yellow fuming acid, and the pale limpid; and the former is more accurately termed in modern chemiſtry *nitrous* acid, and the latter *nitric*. The preciſe difference between the two will be preſently noticed; but it may be here obſerved that the nitrous appears to be the nitric holding a quantity of red nitrous vapour in ſolution.

Common nitrous acid contains, beſides nitrous vapour, a quantity of muriatic and of ſulphuric acid, the former ariſing from a ſmall admixture of common ſalt, or more commonly of muriat of potaſh with the nitre; and the latter from the volatilization of part of the ſulphuric acid added. It is of importance often both in manufacture and in experiment, to get rid of theſe foreign acids, which may be done in the following way: the ſulphuric acid is got rid of by rediſtilling the acid upon about an eighth or tenth of pure nitre in a moderate heat, by which the ſulphuric acid is detained; or elſe nitrat of lead may be added to the mixed acid, which will cauſe the ſulphuric to ſeparate in the form of an inſoluble ſulphat, after which the clear acid may be ſimply decanted off, or (what is much better) ſhould be rediſtilled.

To ſeparate the muriatic acid nitrat of ſilver may be dropped in gradually till all the muriatic acid falls down as muriat of ſilver, after which the clear nitrous acid may be conſidered as pure, or what is better, ſhould be rediſtilled.

The manufacture of this acid in the great way is now performed with equal ſimplicity in this country and with the ſame materials. The proceſs is the following: rough nitre is firſt recryſtallized, then the cryſtals are put (without pounding) into a large glaſs *body*, to which is added half the weight of ſulphuric acid; a glaſs pipe is then luted to the body and made to communicate with an empty receiver, and from this by three or four more pipes with other receivers half full of water, but in this caſe the pipes do not dip in the water. Heat is then applied, and the ſtrong acid condenſes in the empty receiver, whilſt the acid vapour unites with the water of the others, forming the common aqua fortis. To purify the ſtrong acid from the muriatic, the following ſimple method is found ſufficient: a ſmall quantity of diſtilled water is added to ſeveral pounds of the acid, which cauſes a great production of heat and a ſudden guſt of nitrous fumes, and in theſe fumes all the muriatic acid eſcapes, being more volatile than the nitric acid. By ſubſequent boiling the reſt of the nitrous vapour is got rid of, and the acid that remains is a nearly pure nitric acid, of about 1.5 ſpecific gravity. The reſiduary ſulphat of potaſh is moſtly ſold to the alum-makers in Scotland.

The furnace and apparatus of an aqua-fortis diſtiller conſiſt chiefly of a long iron trough filled with ſand, in which the retorts are buried in two rows, ſtanding back to back, and under which is a long brick furnace to heat the ſand. Each retort has its own receiver. Sometimes inſtead of glaſs retorts, very thick iron pots are ſubſtituted with advantage. Theſe will laſt a very conſiderable time before they are ſo much worn as to be unſerviceable.

Nitrous acid is alſo prepared in the large way in ſome countries by diſtilling nitre and clay, ſometimes nitre and martial vitriol. The apparatus for both is the ſame, namely, large earthen pear-ſhaped pots, in which the materials are heated, and earthen globes for receivers. The pots are ranged in a long furnace in a double row, as already deſcribed. When clay is the material uſed a harſh vitriolic clay is ſelected, which is firſt well dried in a ſmall oven, then beaten to rough powder and ſifted. About five parts of nitre are taken to twelve of the clay, and when well mixed, the maſs is wetted either with water or with the weakeſt acidulous phlegm of former diſtillations. The mixture is then put into the pots, and the fire is kindled and kept up with thoſe precautions which practice alone can teach, and the diſtillation continued till all the acid has come over; and the pots are nearly red hot. The acid procured in this way is generally pretty good, but muſt undoubtedly be much weaker than when made with ſulphuric acid and nitre, ſince it is not uncommon to obtain nearly as much nitrous acid as the weight of nitre employed. Indeed it is obvious that it muſt contain all the moiſture originally left in the clay, as well as that employed in the mixture of the clay and nitre. The affinity that acts here in the production of the acid, muſt be that of the clay for the alkali of the nitre, when ſtrongly heated. Beſides this the clays uſed are conſiderably vitriolic, which alſo aſſiſts in the expulſion of the nitrous acid. The reſidue in the retort is a hard half-fuſed earthy maſs, now turned to a deep red (owing to the compleat oxydation of the iron of the clay) and conſiſting of all the earths of the clay, the alkali of the nitre, and a little ſulphat of potaſh, which laſt may be ſeparated by boiling water. This reſidue is called *cement earth of aqua fortis*, and is only uſed as a red earth in ſtaining tiles, bricks, &c.

The proceſs for making aqua fortis by martial vitriol (which is a very good method and much uſed on the continent)[a] is very ſimple. The vitriol is firſt calcined till it falls into a white powder, by which it loſes nearly half its weight of mere water, but little or none of its acid. The calcined vitriol is then mixed with about its own weight of pure nitre, and the mixture is put in ſome works, into earthen, in others in iron pots, to which glaſs receivers are well luted (but with a ſmall vent-hole, for the uncondenſible vapour to eſcape when opened) and the fire is gradually raiſed to redneſs during which the acid diſtills over. In this as in other diſtillations of this acid a fat lute made of clay and linſeed oil is generally employed. The acid procured in this method is more ruddy and fuming than in any other, ſo as to be almoſt brown and opake, and in the proceſs the receiver is often found ſtarred with cryſtalline rays, which again melt down. Theſe are probably ſulphuric acid driven off by the violence of the heat and ſaturated with nitrous vapour, which (as will be elſewhere mentioned) renders this acid cryſtallizable. The reſidue of this diſtillation is a mixture of ſulphat of potaſh and red oxyd of iron, which is eaſily got out unleſs the nitre was mixed with common ſalt, in which caſe it adheres very cloſely to the veſſel. The ſulphat of potaſh is got out by lixivation with hot water, and the inſoluble reſidue is a perfect oxyd of iron of a blood-red colour, called *colcothar*, and when well waſhed and ſifted is much uſed by the looking-glaſs makers to poliſh their mirrors.

Other ſubſtances are occaſionally uſed to diſengage the nitrous acid from nitre, where they can be procured cheap. Sulphat of magneſia is very uſeful for this purpoſe, and in the neighbourhood of ſalt-works it may be ſometimes obtained economically in ſufficient quantity. In this caſe there appears to be firſt a double decompoſition of the ingredients, by which ſulphat of potaſh and nitrat of magneſia are produced, and then the heat drives the nitric acid off, ſo that the reſidue contains both ſulphat of potaſh and uncombined magneſia. It is from very few other ſubſtances however that the nitric acid can be expelled by heat undecompoſed, for when the nitrated alkalies and moſt other nitrated earths are heated, the acid is decompoſed almoſt at firſt, and the products are, not nitric acid, but the elements of this acid diſunited. Hence it is that nitre alone cannot be made to yield its acid by heat.

The diſtilling veſſels are made either of glaſs, or earth, or iron. The former is undoubtedly the beſt material, but is expenſive and liable to accidents. Iron retorts when made very thick at bottom laſt a conſiderable time, but the acid gradually acts upon them and produces much red nitrous vapour, which cauſes the acid to be always exceſſively fuming and high-coloured. In ſome parts of Wirtemberg it appears that they have a way of lining the iron pots with an enamel glazing, which muſt unite all the advantages of iron and glaſs.

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[a] Encycl. Arts & Metiers. Art. *Eau Forte*.

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Nitric acid with its varieties and combinations has been the ſubject of more laborious, profound, and various chemical reſearch than perhaps any other ſubſtance that has ever occupied the chemiſt: and it is well entitled to this attention on account of the readineſs with which it is decompoſed, and the great aſſiſtance which as a chemical reagent it affords in the analyſis of almoſt every other ſubſtance in nature.

From the admirable reſearches of Scheele, Cavendiſh, Prieſtley, Lavoiſier, Berthollet, Davy and many others, we have now acquired a tolerably accurate idea of the nature and combinations of this acid, though ſome important points ſtill remain uncertain.

The appearance and colour of this acid vary conſiderably: in one ſtate it is perfectly limpid and colourleſs, and when poured out ſends forth whitiſh pungent fumes: it is then properly called *Nitric* acid. In another ſtate it is yellow orange or ſometimes of a dark red, emitting copious red fumes, when it is termed in modern nomenclature *Nitrous acid.*

Lavoiſier was of opinion that the difference between theſe two acids conſiſted in the degree of oxygenation, the former being the moſt, the latter the leaſt oxygenated. This diſtinction however, though in one ſenſe it expreſſes the fact, is not perfectly accurate, ſince it will be ſeen by numerous experiments to be preſently related, that the nitric acid becomes converted into the nitrous ſimply by abſorption of nitrous gas without any obvious difference in the degree of oxygenation of the nitric acid itſelf, and conſequently when either acid is ſaturated with an alkali the reſulting ſalt is the ſame in both, and not a more oxygenated ſalt with the nitric, and a leſs oxygenated with the nitrous, as would happen were the acid itſelf different in each. Therefore though the actual quantity of oxygen is greater in a given weight of nitric acid than in the ſame weight of nitrous acid, and though they are both compoſed of azot and oxygen, there appears to be only one ſtate of oxygenation of this acid, and the nitrous gas which makes the difference between the nitrous and nitric acids muſt be here conſidered as doing little more than diluting the acid, and thus diminiſhing the actual quantity of it in a given weight.

Pure colourleſs nitric acid is invariable in its compoſition as far as has hitherto been ſound, and no other varieties of it are produced in diſtillation than what ariſes from the quantity of water with which it is diluted, and with which it will mix in every proportion.

Nitrous acid on the other hand exiſts in an indefinite number of varieties according to the quantity of nitrous gas which it contains, which laſt again is regulated both by the quantity of water preſent, and by the temperature. There is however a point of ſaturation of nitric acid with nitrous gas, at which it aſſumes a blue-green colour. With leſs quantities of nitrous gas the colour is green, olive, red, and yellow. The degree of dilution with water however much influences the colour of the acid.

There is another form of acid which alſo requires particular notice, and it is that which Dr. Prieſtley in his moſt admirable reſearches on this acid called *Nitrous vapour*. It is nitrous acid in the form of red vapour, and conſiſts of nitrous gas holding nitric acid in ſolution. It is produced in ſeveral methods; for example, if to nitrous gas be added oxygen gas, a red cloud is formed, which, if the gaſſes be confined over water, is readily abſorbed, but if no water be preſent it remains as a permanent gas, and this is nitrous vapour. It is alſo expelled from the fuming nitrous acid by heat, and it is produced during the ſolution of biſmuth, and ſome other of the metals in nitric acid, where the action is very violent, the nitrous gas always generated in theſe ſolutions, here diſſolving and carrying up a portion of the acid.

Nitrous gas therefore when in large quantity has a ſtrong tendency to volatilize the acid, and this is more powerful in proportion to its concentration, or inverſely as the water which it contains. The proportions of nitrous gas and nitric acid in nitrous vapour vary conſiderably.

There are four diſtinct ſubſtances concerned in the ſubject of nitric acid, namely: *Nitrous gas*, (whoſe properties have been partly deſcribed under the article *Eudiometry*, and will be further noticed in their place,) *Nitrous vapour*, or a gaſeous combination of nitrous gas and nitric acid, *Nitrous acid*, compoſed of nitric acid, water, and nitrous gas in varying proportions, and *Nitric acid*, or the pure ſaturated form of azot and oxygen, rendered liquid by union with water. Another combination of theſe elements, *Nitrous oxyd* or *gaſeous oxyd of azot*, (*dephlogiſticated nitrous air* of Prieſtley, will be ſeparately deſcribed, and its properties need not here be conſidered.

We ſhall firſt mention ſome circumſtances that occur during the diſtillation of nitric acid that affect the nature of the product. If the acid that comes over be examined at different periods of the diſtillation, the firſt portion will have the greateſt ſpecific gravity and alſo the leaſt colour. Dr. Prieſtley[b] has an experiment to this purpoſe. On receiving the acid at four times, the firſt produce was very pale, and heavier than the ſucceeding portions, effervefced violently with water, emitting red fumes. The ſecond part of the produce was ſtill paler, and alſo effervefced with water. The third part was brown, and mixed with water quietly: the fourth was of a deep orange colour. Prouſt has given the following experiments on this ſubject. A pure nitric acid [c] was prepared by nitre and ſulphuric acid which gave no precipitate with nitrat of barytes, and therefore contained no ſulphuric acid. This was boiled to expell ſome of the ſuperfluous nitrous gas, after which it remained yellow, and of the ſpecific gravity of 1.52. The ſame acid being again diſtilled, the firſt product was 1.51 ſp. g. and leſs yellow: the ſecond product which was ſtill paler was alſo 1.51, but the remainder in the retort which was quite colourleſs, was only 1.47. It may be obſerved that the ſtronger the acid is the leſs heat it requires to be volatilized. Mr. Perceval[d] found on diſtilling two pounds of nitre with one of oil of vitriol and dividing the product into three equal parts, that the firſt portion was 1.494 ſp. gr. the ſecond 1.485, and the third 1.442.

From theſe experiments it is ſhewn to be impoſſible to concentrate the nitric acid by diſtillation, ſo that when the moſt concentrated acid is required, very dry nitre and ſtrong ſulphuric acid muſt be uſed, and the firſt product ſet apart. Mr. Kirwan[e] found that the ſtrongeſt acid he could procure was 1.5543 ſp. gr. at 60° It was yellowiſh red, and exceſſively fuming and volatile. This laſt circumſtance is owing to the ſmall quantity of water contained in the materials before diſtillation, as Dr. Prieſtley had alſo remarked, for the quantity of nitrous gas which nitric acid is capable of diſſolving is inverſely in proportion to the water it contains. Hence it is that even a concentrated pale acid (which however ſtill holds much nitrous gas in ſolution) will give out copious red fumes of nitrous vapour on dilution with water.

The effects of heat on nitric acid are curious and intereſting. Dr. Prieſtley was the firſt that examined this ſubject with accuracy; many of his experiments deſerve particular mention. In moſt of them the acid was incloſed in glaſs tubes hermetically ſealed by melting the end of the glaſs by which all action of external ſubſtances was prevented except heat and light which could permeate the glaſs. Some ſtrong nitric acid of a pale yellow was put into a glaſs tube four feet long and one third of an inch in diameter, the ſpace occupied by the acid being about two inches of the tube, and the open end through which it was introduced was cloſed hermetically. The tube thus prepared was held in the hand at the empty end, and the other preſented to a common fire. The firſt effect was the acid aſſuming an orange colour throughout, after which an orange-coloured vapour appeared above the ſurface of the acid and gradually aſcended higher in the tube, at the ſame time that the acid grew paler and at laſt was left again colourleſs. The red vapour roſe higher and higher in the tube as the heat was continued, leaving a conſiderable ſpace between it and the acid, ſometimes as much as ten or twelve inches of the tube, quite tranſparent. On continuing the heat however the quantity of vapour increaſed and the colour deepened. It was then removed from the fire, when the red vapour preſently deſcended to the ſurface of the colourleſs acid, and entering into it communicated the orange colour. The acid however did not ſeem to be more coloured than at firſt by this proceſs, but on repeating it with the ſame tube for many times, and boiling it for a conſiderable time the vapour changed from orange to green, and the acid remained permanently of an orange-red. The effect of heat upon the coloured acid is quite the reverſe of that on the nitrous vapour, for when the vapour is heated its colour always was found to deepen to a dark orange-red, whereas the coloured acid becomes pale and limpid. If the moſt coloured acid be boiled in *open* veſſels ſo as to allow the eſcape of the nitrous vapour, it remains pale after it is cold, but in cloſed tubes (as above related) the vapour generated by the heat and confined over the ſurface of the acid, is (in part at leaſt) again abſorbed on cooling, and imparts its own orange colour.

That the effect of heat is actually to expell the vapour from the acid, is proved from the circumſtance that when a part of the tube was ſoftened by heat, the preſſure of the vapour within burſt through the glaſs at that part. The degree in which the acid is compreſſed by the nitrous vapour, or (which is the ſame) the degree of denſity of the vapour, much affects the colouring of the acid, ſo that other things being the ſame, the acid will aſſume a higher colour when heated in a ſhort tube than in a long one where the vapour can expand.

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[b] Experiments on Air, vol. i. [c] Journ. de Phyſ. Tom. 49, p. 59. [d] Royal Iriſh Tranſ. vol iv. [e] Ibid. p. 13.

The contact of air was not found at all neceſſary to the colouring of nitric acid, for on confining ſeparate portions of acid in tubes with different ſpecies of air and in vacuo, and applying an equal degree of heat to all, they all aſſumed nearly the ſame ſhade of colour in a given time.

The ſmalleſt quantity of combuſtible (or phlogiſtic) matter will almoſt immediately render pale nitric acid high coloured when added to it, and the ſame change takes place in a ſhort time even when the matter is only contiguous to it, as for example when the acid is kept in a phial ſtopped with a cork.

Fuming nitrous acid is made colourleſs by ſimple expoſure to the air, but this ſeems to be effected ſolely by the great dilution which it gradually undergoes from the water which it abſorbs from the atmoſphere. Thus Dr. Prieſtley found on expoſing a glaſs tumbler containing ſome of the acid to this open air, that in a day or two it became colourleſs, and for ſeveral months it gained weight notwithſtanding the loſs which it muſt have undergone by evaporation, till it had acquired double its original weight, and of courſe was proportionally dilute.

Light alſo has a ſimilar effect with heat in colouring pale nitrous acid, which, as the ſame excellent obſerver has remarked, takes place in a few days, but it appears to act only on the vapour of the acid, for even the paleſt acid when concentrated is conſtantly ſending forth a vapour which is at firſt colourleſs, and this vapour when coloured by the light ſeems to react on the acid and to effect a ſimilar change. Light however is not neceſſary to aſſiſt the action of heat ſince the ſame change was found by heating the acid in opake veſſels as in tranſparent ones. To prove that the colorific action of light was exerted only on the vapour of the acid, Dr. P. made a quantity of colourleſs acid by boiling the common yellow acid haſtily, and letting it cool in the dark, and put different portions of it in phials, ſome of them quite full, others only half full and with different ſpecies of air incumbent upon them, and expoſed them all to the ſun's rays for a few days. After this time the acid in all the phials that were only half full was conſiderably coloured, but in the full bottles it remained as colourleſs as water. The ſame effect was produced on the vapour when a vacuum was made over the acid as ſoon as introduced. Alſo on throwing the ſtrong light and heat of a lens on the upper part of a phial half full of acid, the vapour became ſpeedily coloured, and this being imbibed by the acid gradually tinged it, the colour ſpreading from above downwards.

Whenever pale nitric acid is made to yield a quantity of red nitrous vapour there is at the ſame time a production of oxygen gas, and alſo as appears from Dr. Prieſtley's experiment, a quantity of azotic gas.

He found on filling a tube with the pale acid, boiling it within the tube and cloſing it hermetically when boiling, (in which way almoſt every particle of atmoſpheric air is excluded by the boiling vapour) that after the acid has been coloured by heat and red vapour formed, a quantity of air ruſhed out of the tube when opened, which was found to conſiſt of a large proportion of oxygen and ſome azotic gas. Thus it appears that oxygen gas and nitrous vapour can exiſt in the ſame place and in a ſtate of conſiderable condenſation, without mutual decompoſition.

The action of heat on nitric acid therefore appears to be the following: ſuppoſing the acid to contain no ſeparable portion of nitrous gas in ſolution, the heat appears firſt to decompoſe part of the acid into nitrous gas and oxygen, and theſe being expelled as ſoon as formed, carry up in ſolution a certain portion of undecompounded acid, and the three together form *nitrous vapour*. The oxygen however ſeems not to be an eſſential conſtituent of the vapour and perhaps is only mechanically mingled with it. If the acid is cloſely confined in a veſſel which it does not fill, the vapour remains unchanged in the empty ſpace above the acid, and when the heat is withdrawn, a portion of it (more or leſs according to the denſity and elaſticity) is again abſorbed by the acid and renders it coloured. A part at leaſt of the oxygen gas remains in the gaſeous ſtate unaltered, but it is by no means improbable that as ſoon as the heat is removed, another part of the oxygen may again combine with the nitrous gas which it had quitted and return into the body of acid.

Where pale nitric acid is encloſed in veſſels which it entirely fills it is probable that no continuance of heat could render it coloured, for as the colouring is owing to its diſſolving nitrous gas, and as this gas cannot be formed without the previous decompoſition of a portion of acid and production of oxygen gas, where no room is afforded for the eſcape of oxygen in its proper gaſeous form, its production muſt be prevented. But on the other hand the narrower the vacant confined ſpace is, above the acid, the more ſpeedily will it become ſaturated with nitrous gas, owing to the conſtantly accumulating preſſure of the oxygen gas above it.

The effect of heat on nitric acid already ſaturated with nitrous gas, or in the coloured fuming ſtate, and *unconfined*, is ſimply to expell the nitrous gas, and a portion of the acid in the form of nitrous vopour, and thus to leave the acid pure and colourleſs.

The more concentrated the acid is the greater is the quantity of nitrous gas which it will abſorb, and at the ſame time the eaſier will it again give out the gas when heated.

It may appear contradictory to experience that nitrous gas, which in its natural ſtate is ſo greedy of oxygen and unites with it ſo readily, ſhould appear to mix with it in combination with vaporized nitric acid without contracting any union with it. It is by no means improbable however that this is only during the application of heat, which is conſtantly obſerved to counteract the chemical union of gaſeous bodies, and beſides, the preſence of the acid vapour may operate in preventing this union, for it does not neceſſarily follow that the affinities of nitrous gas ſaturated with acid vapour ſhould be the ſame as ſimple nitrous gas.

The union of nitrous gas with nitric acid both diminiſhes its ſpecific gravity and gives it a prodigious tendency to volatiſization, and as will appear from ſome experiments which will be preſently mentioned, this acid may be totally diſſipated in red nitrous fumes when the quantity of nitrous gas or vapour is exceſſive.

The compoſition of nitrous vapour is certainly various, and it may exiſt with an exceſs either of oxygen or of azot according to the way in which it is procured, and by this Berthollet explains ſeveral apparent contradictions in its phenomena.

The analyſis of nitrous vapour is extremely difficult, owing to the impoſſibility of confining it unaltered in jars by any known fluid, as it acts powerfully on almoſt every fluid in nature. Dr. Prieſtley made many attempts to procure it in quantities and tolerably uniform in its compoſition. He found it produced readily by the rapid ſolution of biſmuth in nitric acid, but the method on the whole the moſt convenient was to diſſolve lead in dilute nitric acid, and evaporate the ſolution to compleat dryneſs. This left a white nitrat of lead, which when put into a ſmall glaſs tube or retort and heated ſtrongly gave a large quantity of red nitrous vapour in conſiderable purity. This ſpecies of nitrous vapour however ſeems to differ from that produced by the ſuper-ſaturation of nitrous gas with oxygen confined by mercury, and from that produced by heat from nitric acid, for this from the nitrat of lead abſorbs oxygen from the air in the ſame way as common nitrous gas only not ſo rapidly. It is with this nitrous vapour that Dr. Prieſtley made many experiments on its abſorption by different bodies, ſome of which are as follows:

Water impregnated with this vapour was increaſed one third in bulk, and in this ſtate when left at reſt was conſtantly again exhaling the vapour with great force ſo that it could with difficulty be kept in cloſe-ſtopped phials. The colour was bluiſh green. On pouring a little into a glaſs and blowing away from the ſurface the red vapour iſſuing out, the colour of the liquor gradually changed to pale yellow like common nitrous acid, and it was in every reſpect ſimilar to this acid. The acid made in this way is alſo purer than the common ſpirit of nitre, as it contains no admixture of muriatic acid.

Oils abſorb this vapour readily and in general are ſtiffened and coagulated, as will be further mentioned under the article *Oil.*

Sulphuric acid abſorbs nitrous vapour. On putting a little of the acid into a phial full of the vapour and ſhaking it for a time, the red colour of the air diſappeared and a vacuum was formed above the acid, which laſt became of a light blue colour exhaling a white vapour. On putting ſome of this acid into a glaſs and gently pouring water on it no change was obſerved at firſt, but on ſtirring the mixture great heat was excited, and a vaſt quantity of red vapour was expelled with vehemence. The acid after this ſeemed to have loſt all that it had before abſorbed and to be merely ſulphuric acid diluted with water. When concentrated acid is fully ſaturated with nitrous vapour and ſuffered to remain at reſt for a time it cryſtallizes, as will be further mentioned under the article *Sulphuric acid.*

The muriatic acid alſo abſorbs the nitrous vapour and in conſequence aſſumes a deep orange colour, but without much increaſe of bulk, and is converted into a very powerful *nitro-muriatic acid* or aqua regia.

Having thus given a ſhort abſtract of ſome of Dr. Prieſtley's moſt important experiments on nitrous acid, we proceed to mention others by which it has been attempted to aſcertain the exact proportion of the conſtituent parts of nitric acid and its ſeveral modifications.

Chemiſtry is indebted to Mr. Cavendiſh for the important diſcovery of the true nature of nitric acid; this eminent philoſopher having compoſed the acid by paſſing the electric ſpark for a vaſt number of times through a mixture of azotic and oxygen gaſſes, and thus demonſtrated that azot is its radical or baſis.[e]

The apparatus employed in theſe intereſting experiments conſiſted of a glaſs tube bent in the form of the letter V, which after being filled with quickſilver, was inverted into two glaſſes of the ſame fluid. The air to be tried was then introduced into one of the legs of the tube, and in the other were thrown up teſt liquors, or other fluids as required. A communication was then made with a powerful electric machine, ſo as to take ſparks ſucceſſively through the air in the tube. Common air alone was firſt tried (which conſiſts of about 77 *per cent.* of azot and 23 of oxygen) and litmus liquor was introduced in contact with it up the other leg of the tube. On paſſing the ſpark through it repeatedly the litmus liquor acquired a red colour, and the air was diminiſhed. When lime-water was introduced inſtead of the litmus, not the leaſt turbidneſs was perceived, though the air went on diminiſhing to two-thirds of its original bulk. A mixture of azotic and oxygen gaſſes was then tried, and the lime-water as before remained clear, but on adding ammonia a brown ſediment appeared. This conſiſted of carbonat of lime mixed with a little mercury, which the electric ſpark had oxydated, and hence both the lime and the mercury muſt have been diſſolved in the water of the lime-water, by ſome acid, which acid was afterwards proved to be the nitric.

Mr. Cavendiſh afterwards found that the production of nitric acid from theſe two airs, was much haſtened by electrizing them in contact with a ſubſtance for which the acid when formed has a great affinity, and accordingly ſoap-lees or cauſtic potaſh was uſed.

One leg of the tube being filled with a mixture of azot and oxygen, and the other with the alkaline ſolution, ſparks were taken through the air for a great number of times, after which the alkaline liquor was found compleatly ſaturated with acid, and on being evaporated to dryneſs a ſmall quantity of a ſalt was left, which was evidently nitre. In ſeveral experiments however when the electrization was continued ſo long that the acid produced was more than ſufficient to ſaturate the alkali, the exceſs of acid diſſolved a little of the mercury by which it was confined, and nitrat of mercury was alſo found mixed with the nitrat of potaſh. The particular teſts by which the preſence of nitrat of potaſh and nitrat of mercury were detected need not be here related; it is ſufficient to obſerve that they were perfectly ſatisfactory.

From theſe moſt valuable and fundamental experiments it is proved, that nitric acid conſiſts of azot of oxygen in certain proportions, and that the electric ſpark is capable of making them unite in that form and proportion which is neceſſary to conſtitute this acid, whatever be the actual proportions of theſe gaſſes in contact with the electric ſpark. Hence too we find that nitric acid is always generated whenever the electric ſpark is taken in the open air.

The proceſs as given by Mr. Cavendiſh is extremely laborious, and requires great perſeverance, as even with a powerful machine, and continuing the electrization for ſeveral days, only a very few grains of nitre are produced in the potaſh ſolution.

Mr. Henry[f] has given the following very accurate directions for performing this experiment: let a ſtraight tube prepared for electrical purpoſes, be filled with and inverted over mercury. Paſs into it a portion of common air, or, in preference, a mixture of azotic gas with twice its weight of oxygen. Let an iron wire lengthened out with one of platina, be introduced within the tube, ſo that only the latter metal may be in contact with the mixed gaſſes, and let the end of this wire be diſtant $\frac{1}{4}$ of an inch from the extremity of the upper one. Then paſs a ſeries of electric ſhocks through the gaſſes for ſeveral hours. The mixture will gradually leſſen in bulk, will redden litmus introduced within it, will give the ſmell of nitrous acid, and will neutralize a few drops of potaſh, and produce nitre.

On account however of the difficulty of procuring any tolerable quantity of nitric acid in this way, the proportion of its ingredients cannot be inferred with much accuracy. Mr. Cavendiſh did not find any very ſatisfactory agreement in the actual quantities of the gaſſes abſorbed in the different experiments, but on the whole it appears from them, that ſomewhat more than twice as much pure oxygen as azot conſtitutes nitric acid.

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[e] Phil. Trans. Vol. lxxv. and lxxviii.

[f] Epitome of Chem. 4th Edit.

A very intereſting fact relating to the production of nitrous acid from ammonia and a metallic oxyd was diſcovered in 1789 by the Rev. Iſaac Milner.[g] The production of ammonia from nitrous acid and iron in ſome circumſtances, had been before diſcovered by Dr. Prieſtley, which led Mr. M. to endeavour to reverſe the experiment, and produce nitrous acid by the decompoſition of ammonia by means of a metallic oxyd, when in the act of giving out oxygen. It was made in the following manner: the middle part of a clean gun-barrel was filled with black oxyd of manganeſe, rammed in gently and in coarſe powder, ſo as to admit the paſſage of vapour through. The barrel was then made red-hot in the middle, and at one end was luted a ſmall retort filled with cauſtic ammonia, which was made to boil by a lamp heat, and the ammoniacal vapour was thus forced through the red-hot manganeſe. Nitrous fumes ſoon began to appear at the other and open end of the gun-barrel, and a conſiderable quantity of air was collected which was clearly nitrous. Owing to the impoſſibility of exactly adapting the quantity of alkaline vapour to the oxygen which the manganeſe is giving out, there will be always found a great variety in the gaſeous products, but nitrous gas is always given out and generally with the uſual appearance and ſmell of the red nitrous vapour when it comes in contact with the air. Sometimes however when much ammonia is paſſing through the barrel and but little oxygen giving out, the product is a mixture of nitrous gas with ammonia, and on coming in contact with air the nitrous gas becomes for an inſtant red by changing into nitrous vapour, after which it unites chemically with the alkali, and the receiver is filled with white clouds of nitrated ammonia.

In this intereſting experiment the ammonia is reſolved into its elements, azot, and hydrogen, and the azot uniting with the oxygen of the manganeſe forms nitrous gas or nitrous vapour, according to the degree of ſaturation.

Nitric acid when in vapour is decompoſed by a red heat, and the products are very pure oxygen gas, nitrous gas, or nitrous vapour, or if the decompoſition be compleat, azotic gas. To give the vapour of boiling nitric acid a red heat, Dr. Prieſtley adopted his own ingenious method, of heating red-hot the middle of a glazed earthen tube, looſely filled alſo with fragments of hard pottery to increaſe the red-hot ſurface, and paſſing through it the boiling vapour expelled from a quantity of pale nitric acid heated by a lamp at the other end. In this way the products were a large quantity of the pureſt oxygen gas and abundance of nitrous gas, nitrous vapour, and ſome undecompoſed acid.

Many other ſeries of experiments have been made by ſkilful chemiſts, to aſcertain the exact proportion of the conſtituent parts in nitric acid and its varieties. As our limits will not allow us to relate them all, we ſhall conclude this part of the ſubject with thoſe of Mr. Davy,[h] which yield to none in accuracy, and are generally allowed by chemiſts to form as near approximations to truth, as can be expected in this peculiarly difficult and delicate part of chemical analyſis.

The methods uſed to eſtimate ſeparately the conſtituents of nitric acid, have been the following: *1ſt.* By the decompoſition of pure nitre either by heat alone or by charcoal or ſome other combuſtible. But this proceſs is attended with almoſt inſuperable difficulties; a great variety of products are formed in this way, all of which would require a ſeparate analyſis with an infinite number of precautions and neceſſary corrections, and a portion of the acid is volatilized without decompoſition. *2dly.* By the immediate combination of oxygen and azot, in Mr. Cavendiſh's method. But this though ſimpler than the former, is nearly impracticable on account of the extreme laborioufneſs of the proceſs and the very ſmall quantity of acid product: and accordingly we find no ſufficiently ſatisfactory agreement even in the careful experiments of the diſcoverer. *3dly.* By the combination of nitrous gas and oxygen, as in the common eudiometrical trials, and the ſubſequent abſorption of the generated acid by a given quantity of water. But Mr. Davy found that the reſiduary azot, which is always mixed with the pureſt nitrous gas and oxygen, in whatever way obtained, carries with it a variable quantity of nitrous acid vapour, of different compoſition from the acid abſorbed, and thus renders the experiment inaccurate. The method Mr. Davy adopted was, to exhauſt a glaſs globe of its common air, then to throw in a given quantity of nitrous gas, and after it oxygen gas ſomewhat more than ſufficient to ſaturate it, then to add water to abſorb the nitric acid formed (and which before the addition of the water remained in the ſtate of permanent vapour); then to allow common air to enter to take the place of the condenſed nitrous acid vapour; then to add ammonia to abſorb the acid which the water would not condenſe, and thus by ſubſequent calculations founded on the ſpecific gravity of the gaſſes uſed and the acid product, to find a *ſtandard acid*, the compoſition of which ſhould be accurately known. It will not be unintereſting to give in a general way the particulars of the ſtandard experiment, to ſhew more clearly the manner of effecting it, and alſo the numerous data and calculations required to come at the reſult.

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[g] Phil. Tranſ. Vol. 79.

[h] Reſearches.

The firſt ſtep was to aſcertain by actual experiment the ſpecific gravity of all the gaſſes to be employed. The *nitrous gas* was procured from a ſolution of mercury in nitrous acid, and its purity tried by agitating a ſmall portion with a ſolution of ſulphat of iron, by which the whole of the nitrous gas was abſorbed, and nearly all the azot mixed with it was left: 100 cubic inches of pure nitrous gas were found to weigh 34.3 grains at 56° therm. and 30.9 bar. The *oxygen gas* was obtained from oxyd of mangane ſe by ſulphuric acid, and its purity tried by nitrous gas and ſulphat of iron. Hence 100 cubic inches of pure oxygen gas at the above heat and preſſure, were found to weigh 35.09 grains. The *azotic gas* was obtained from the reſidue of common air after the oxygen had been abſorbed, and 100 cubic inches weighed 30.43 grains. Laſtly the *atmoſpherical air* of the laboratory was analyſed, and 100 cubic inches of it weighed 31.9 grains. The experiment was then conducted in the following manner.

A glaſs balloon with a ſtop-cock, of the capacity of 148 cubic inches, was taken for the purpoſe of combining the gaſſes. The whole weight when full of common air was 2066.5 grs. It was then partially exhauſted by the air pump, till it loſt 32 grains, ſo that 15 grains of air remained in it. After this 82 cubic inches of nitrous gas were thrown in, which made the outſide of the balloon ſenſibly hot, and produced an orange coloured vapour within. Some common air then entered accidentally, the weight of which was noted. Then 70 cubic inches of oxygen gas were introduced, whereby the heat was increaſed and the colour changed to a very dark orange. To abſorb the nitrous acid formed, 41 grains of water were introduced, by which the dark orange colour rapidly diminiſhed and ſoon diſappeared. To aſcertain the quantity of vapour condenſed by the water, the vacuum produced thereby was filled with common air, of which 51 cubic inches, or 16.5 grains, ruſhed in. The acid liquor in the globe (produced by the water and the acid vapour which it had condenſed) was then examined, and was found ſlightly green, and of 1.301 ſpecific gravity.

To find whether any unabſorbed nitric acid remained in the veſſel, 13 grains of liquid ammonia were added, which produced a white cloud with the remaining acid vapour, after which all the reſidual gaſſes were diſplaced by common air. The balloon was weighed after every proceſs. By calculations from the above experiment it was found that 57 cubic inches of acid gas were formed, weighing 40.56 grains; this was compoſed of 27.6 grains, or 80.5 cubic inches of azot, and 12.96 grains, or 36.9 cubic inches of oxygen, which, condenſed by 41 grains of water, produced an acid of 1.301 ſpecific gravity. Therefore, reducing the whole to centenary proportion, 100 cubic inches of *aeriform nitrous acid* (or nitrous gas ſaturated with oxygen and excluded from the contact of water or any other ſubſtance that could act upon or abſorb it) at temperature 55° and 30.1 bar. weigh 75.17 grains.

Secondly: 100 grs. of this gaſſeous acid are compoſed of 68.06 nitrous gas and 31.94 oxygen; or (aſſuming that 100 parts of nitrous gas conſiſt of 55.95 oxygen and 44.05 azot, as will be mentioned under the article *nitrous gas*) of about 30 azot and 70 oxygen.

Thirdly, 100 grs. of a pale green ſolution of this acid in water, of 1.301 ſp. gr. are compoſed of 50.62 water and 49.38 acid.

A ſtandard acid of known compoſition was thus obtained, but it was dilute, and many of the ſubſequent experiments were to be performed on the concentrated acid. But as there is no known method of concentrating a dilute acid without partial decompoſition, Mr. D. was obliged to make a dilute acid compoſed of a given quantity of the ſtrongeſt yellow acid of 1.5 ſp. gr. and water, which ſhould as nearly as poſſible reſemble in weight and colour the ſtandard acid produced by the union of the gaſſes. This after many trials in a ſmall graduated glaſs tube was found to be effected by combining at 40° therm. 90 grs. of the yellow acid of 1.5. ſp. gr. with 77.5 grs. of water, and hence the compoſition of the above yellow acid was inferred to be, in 100 grs. 91.9 of *true* nitrous acid (or ſuch as exiſts in the aeriform ſtate ſaturated with oxygen) and 8.1 grs. of water, ſuppoſing the relative quantities of oxygen and azot to be the ſame in each.

But on the other hand the acid of 1.5 here uſed was the *yellow* or *nitrous* acid, and it became a further queſtion to aſcertain the preciſe difference between this and the *pale nitric* acid of the ſame ſpecific gravity. This was attempted by heating the yellow acid, which, as already mentioned in this article, drives the ſuperabundant nitrous gas out of the acid and leaves it pale and colourleſs. One hundred and fifty grains of the yellow acid of 1.5. ſp. gr. were put in a ſmall matraſs with a curved tube, and on the firſt application of heat the colour changed to a deep red. In a ſhort time a red vapour appeared in the tube and was conveyed into a noted weight of water by which it was abſorbed, giving the water a bright green colour. By continuing the heat the acid became pale, and when cold was weighed and had loſt 15 grs. but its ſpecific gravity was *leſſened* to 1.491 and 2¼ cubic inches of nitrous gas were collected that had paſſed through the water unabſorbed. This experiment however was found inconcluſive, ſince the nitrous gas expelled from the yellow acid in the proceſs of its converſion to the pale, had carried off with it in the form of nitrous vapour a portion of acid diſſolved in the gas. It was neceſſary therefore to reſort to the ſynthetical method, or that of impregnating a given portion of the pale acid with nitrous gas. In a proper apparatus 90 grs. of the pale acid of 1.504 were introduced and nitrous gas was thrown up, whereby the acid became warm and the colour changed firſt to a pale ſtraw, and as more of the gas was abſorbed, to a bright yellow. By this 8 cubic inches of nitrous gas were abſorbed, the acid gained 3 grs. in weight, and the ſpecific gravity was diminiſhed to 1.5. Theſe data were aſſumed as the means of comparing the relative compoſition of the pale and the yellow acid, both of 1.5 ſp. gr.

The power of abſorbing nitrous gas and the change produced thereby on the acid was carried ſtill further, and the ſame yellow acid of 1.5 when returned into the apparatus became gradually, as the gas paſſed into it, dark orange, light olive, dark olive, then of a muddy green, and laſtly a blue green. This was the utmoſt change that the acid could aſſume, after which the nitrous acid appeared to paſs through the acid unaltered. The increaſe of weight was only 1 grain and the ſpecific gravity of the acid was now only 1.474. On account however of the large quantity of nitrous gas which paſſed through unabſorbed, and the acid which was volatilized along with it, no accurate deductions could be drawn from the experiment, except the great and ſucceſſive changes of colour and the great diminution of ſpecific gravity. A quantity of this blue green acid ſaturated with nitrous gas was then put into a ſmall glaſs apparatus and ſlowly heated, when the nitrous gas was again given out with rapidity and the acid paſſed back through the ſucceſſive colours of green, olive, red, and orange, to a perfectly colourleſs ſtate, and when cold its ſpecific gravity was then *increaſed* from 1.474 to 1.502. The quantity of blue green acid uſed was 94.25 grs. and it had loſt 31 grs. in paſſing to the colourleſs ſtate. The inferences from theſe and many other experiments (which from their complicated nature, and the numerous corrections required, on account of the ſolubility of nitric acid in nitrous gas are only given as approximations to the truth) and the relative proportion of ingredients in the different varieties are given by Mr. Davy in the following tabular form.

100 parts	Sp. Gr.		Nitric Acid.	Water.	Nitrous Gas.
Pale nitric acid - - -	1.504	contain of	91.55	8.45	0.
Yellow nitrous - - -	1.502		90.5	8.3	1.2
Bright yellow - - - -	1.5		88.94	8.1	2.96
Dark orange - - - -	1.480		86.84	7.6	5.56
Light olive - - - - -	1.479		86.	7.55	6.45
Dark olive - - - - -	1.478		85.4	7.5	7.1
Bright green - - - -	1.476		84.8	7.44	7.76
Blue green - - - - -	1.475		84.6	7.4	8.

In a ſecond table the reſpective quantities of oxygen and azot in different varieties of the acids are thus given, but it muſt be obſerved that the oxygen ſpecified is only that which belongs to the acid, and not to the water with which it is neceſſarily combined to give it a liquid form.

100 parts		Azot.	Oxygen.		Azot	Oxygen.
Pale nitric acid	contain of	29.50	70.50	or, in the proportion of	1	2.389
Bright yellow acid		29.90	70.10		1	2.344
Orange coloured		30.37	69.63		1	2.292
Dark green		30.92	69.08		1	2.230

The quantities of true nitric acid (or that produced in the aeriform ſtate by ſaturating nitrous gas with oxygen) in ſolutions of different denſities is thus given, being inferred from mixtures of the ſtandard liquid acid with known weights of water.

100 parts of Nitric Acid of ſp. gr.		True Acid.	Water.
1.5040	contain	91.55	8.45
1.4475		80.39	19.61
1.4285		71.65	28.35
1.3906		62.96	37.04
1.3551		56.88	43.12
1.3186		52.03	47.97
1.3042		49.04	50.96
1.2831		46.03	53.97
1.2090		45.27	54.73

The dilute nitric acids undergo ſimilar changes by nitrous gas as the concentrated, but the quantity of gas which the acid is capable of abſorbing diminiſhes in proportion to the degree of dilution. Mr. D. found that 330 grs. of acid of 1.36 ſp. gr. became blue green after 50 cubic inches of gas had been paſſed through it, and the ſpecific gravity was leſſened to 1.351. It had gained in weight but 3 grains and when heated only 7 cubic inches of nitrous gas were collected.

There is a difficulty in accounting for all the changes of ſpecific gravity in the experiments above mentioned. Nitric acid undoubtedly loſes ſpecific gravity by abſorbing nitrous gas, and by a direct experiment a pale acid of 1.504 was reduced to 1.474 by compleat ſaturation with the gas. And on the other hand the ſame acid of 1.474 after being heated and brought to the ſtate of the pale nitric returned to the ſpecific gravity of 1.502 or nearly to its original weight. But on the other hand the yellow acid of 1.5 *loſt* ſpecific gravity by loſing nitrous gas and was reduced to 1.491. Probably this apparent contradiction depends upon the variable quantity of nitric acid united with the nitrous gas in the form of nitrous vapour, in which it always exiſts when expelled from the coloured acids.

Mr. Kirwan in his excellent experiments on the ſtrength of acids purſues the following method in eſtimating the quantity of *real acid* in ſolutions of nitric acid of different denſities.

The ſpecific gravity of the moſt concentrated nitrous acid which he could produce was 1.5543 in the temperature of 60°. This was highly fuming and yellow, and therefore conſiſted of nitric acid holding nitrous gas in ſolution. This laſt circumſtance however is neglected. He conſiders this as the *ſtandard acid:* and by calculations which will be given in the appendix he deduces the proportions of ſtandard in 100 parts of diluter acids whoſe ſpecific gravity is given. Thus for example, 100 parts of an acid of 1.4731 ſp. gr. are found by calculation to contain 90 parts of the ſtandard acid of 1.5543 and 10 parts of water. But the ſtandard itſelf is a mixture of water with an unknown quantity of *real* acid, and to determine this quantity Mr. Kirwan purſues the following method which is applied (*mutatis mutandis*) to the other acids.[1] Firſt, a known quantity of alkali is ſaturated with an acid whoſe ſpecific gravity is known, and whoſe proportion of ſtandard acid is determined by previous calculation. Then another ſolution is made of a known quantity of the ſame neutral ſalt as that produced by the union of the acid and alkali employed, and both ſolutions are brought to the ſame ſpecific gravity by adding water to the heavieſt. This gives two ſolutions which may be preſumed to hold equal quantities of neutral ſalt, and the quantity of ready-formed ſalt in one of the ſolutions is known by actual experiment, and the quantity of alkali and ſtandard acid required to make this quantity of neutral ſalt in the other ſolution is alſo known by experiment. From theſe data the quantity of real acid in the ſtandard may be readily inferred, underſtanding by the term *real* acid an acid of the degree of concentration that exiſts in the dry neutral ſalt combined with the alkali. An example will render this clearer to the reader. A quantity of concentrated ſoda was heated to redneſs in a ſilver crucible whereby all the water of cryſtallization was expelled, and it was then diſſolved in ſuch a quantity of water that 367 grs. of the ſolution contained 50.05 of the dry alkali. This quantity was then ſaturated with 147 grs. of nitric acid of 1.2754 ſp. gr. and which contained 45.7 per cent. or 66.7 of the ſtandard acid of 1.5543 ſp. gr. The carbonic acid loſt by the ſolution was 14 grs. ſo that the quantity of ſoda alone in it was 50.05—14, or 36.05 grs. The ſolution was then lowered by water to 1.0401 ſp. [gr. which was found by a ſeparate experiment to be the degree of denſity of water containing $\frac{1}{16.901}$ of its weight of dry nitrated ſoda. The firſt ſolution weighed 1439 grs. and hence it muſt have contained $\frac{1439}{16.901}$ = 85.142 grs. of nitrated ſoda. The quantity of ſoda employed was 36.05 grs. and the quantity of ſtandard acid was 66.7 and the ſum of theſe is 102.75. But of this quantity only 85.142 entered into the combination of the ſalt and therefore the difference between 85.142 and 102.75, or 17.608, muſt have been the mere watery part contained in the 66.7 grs. of the ſtandard acid. Therefore 100 of the ſtandard acid contain 26.38 of water and 73.62 of *real* acid or ſuch as exiſts in combination in dry nitrat of ſoda: and 100 parts of this ſalt contain 42.35 of alkali and 57.65 of real acid, which is equivalent to 78.33 of the ſtandard.

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[1] Iriſh Tranſ. vol. iv. p. 17 and 35.

In theſe experiments on nitric acid it becomes a queſtion to determine how far changes of temperature affect the ſpecific gravity. Mr. Kirwan found that the ſtrongeſt acid was the moſt expanded by heat and contracted by cold. From the reſult of many experiments he finds that on an average the variation of ſpecific gravity for every ſingle degree between 60° and 70° in an acid whoſe denſity at 60° is from 1.3 to 1.4 is .0005 and for the variation between 44° and 60° is .0004. An acid of 1.263 ſp. gr. at 60° gains loſes for every degree between 60° and 70° .00043, and for every degree between 60 and 45° the variation is .00036.

The affinities of nitric acid for the alkalies and earths are in the following order, barytes, potaſh, ſoda, ſtrontian, lime, magneſia, ammonia, glycine, alumine, zircon.

The combinations of the nitric acid with alkaline earthy and metallic baſes, are called Nitrats, and will be deſcribed in their proper place.

The ſame theory that ſuppoſed the ſuperior degree of oxygenation of the pale nitric over the coloured nitrous acid, has given the term *nitrites* to the ſalts of the latter acid. But this is founded on an erroneous idea of the difference between the two acids, and of the whole imagined genus of nitrites, the nitrite of potaſh alone has been ever produced, and this not by the direct combination of the nitrous acid and potaſh but by the partial decompoſition of common nitre. Its properties will be mentioned under the article *nitrite.*

NITRO-MURIATIC ACID. *Aqua Regia. Konigwaſſer.* Germ.

The term nitro-muriatic acid is not meant to deſignate any particular acid or modification of acid but ſimply a mixture of nitric or nitrous and muriatic acid, or ſometimes muriat of ammonia, which when united produce a very important agent in many chemical operations. It is particularly as a ſolvent for gold that this combination (which is very ancient) has been known, and hence it was termed by the alchemiſts *aqua regia,* (gold being with them the *king* of metals) and is nearly the only ſubſtance that can diſſolve this noble metal. The compoſition of the aqua regia fitted to diſſolve gold has been deſcribed under that metal. Platina alſo, like gold, is inſoluble in either of theſe acids ſingly, but yields to a mixture of the two, but in different proportions. Antimony alſo is ſcarcely ſoluble in any acid but the nitro-muriatic, and the compoſition of the mixture the beſt fitted for this purpoſe is ſtill different from the others.

Berthollet in his excellent and profound eſſay on chemical ſtatics has ſome good obſervations on this acid. When pale nitric and muriatic acid are mixed, an efferveſcence quickly takes place, the liquid becomes of a high amber-red colour, and a very pungent vapour is extricated, obviouſly ſmelling very different from the vapour of the nitrous or muriatic acid ſingly, but cloſely reſembling the oxymuriatic acid gas, which is the actual vapour given off. This is formed by a partial decompoſition of a portion of nitric acid which ſurrenders part of its oxygen to the muriatic acid gas, whilſt the remainder is nitrous gas, which diſſolving in the acid gives the high colour, and may be driven off by ſaturating the acid with an alkali or earth. The above decompoſition of nitrous acid, and evolution of oxymuriatic acid ceaſes when the mixed acid is ſaturated with the nitrous gas, and hence the fuming nitrous acid which already contains much nitrous gas, gives leſs oxymuriatic vapour than the pale acid. If nitrous gas be mixed with oxymuriatic acid gas over mercury or over very little water, the nitrous gas takes the exceſs of oxygen from the oxymuriatic, and vaporized nitrous acid ſucceeds, but if ſufficient water be preſent, this acid vapour, together with the muriatic gas ſeparated from the oxymuriatic, is abſorbed by the water, and liquid nitro-muriatic acid is produced.

Dr. Prieſtley[a] has found that a very powerful aqua regia which diſſolves gold with great rapidity may be formed by impregnating liquid muriatic acid with the nitrous acid vapour (deſcribed in the laſt article). The proportion of conſtituent parts here widely differs from thoſe of the common aqua regia for gold, which laſt is uſually made by three fourths of nitric and one fourth of muriatic acid; whereas in making the other acid the liquid muriatic acid hardly increaſes in bulk by ſaturation with the nitrous vapour. Dr. P. alſo tried to form a nitro-muriatic acid that would diſſolve gold by impregnating nitrous acid with muriatic acid gas, but without ſucceſs, as the liquor would not touch this metal. As ſoon as the muriatic acid receives the nitrous vapour it changes from a pale ſtraw to a deep orange, much deeper than nitrous acid alone can be brought to.

When nitro-muriatic acid is ſaturated with an alkali the nitrous gas which it had abſorbed is given out, and the liquor duly evaporated gives both a nitrat and muriat of the alkali uſed. But when the acid is ſaturated with a metal the reſulting ſalt is uſually a ſimple muriat, the nitric acid having been employed to oxygenate the metal and thus to render it (in moſt inſtances) ſoluble in the muriatic acid, to which moſt metallic oxyds have the ſtrongeſt affinity.

NITRAT OF POTASH. NITRE. SALTPETRE.

Nitre is a neutral ſalt compoſed of nitric acid and potaſh in a ſtate of perfect mutual ſaturation. Its primitive cryſtalline form is that of a rectangular octohedron, compoſed of two pyramids applied baſe to baſe, in ſuch a manner that two oppoſite ſides of the upper pyramid form with the correſponding ſides of the lower one angles of 120°, while the two other oppoſite ſides form with their correſponding ones angles of 111°. This figure however is of very rare occurrence. When the ſummits of the pyramids are deeply truncated, the reſult is a bevilled rectangular table, which is by no means unfrequent. But the moſt uſual form which this ſalt aſſumes is that of the common quartz cryſtal, viz. a ſtrait ſix-ſided priſm terminated at each extremity by a ſix-ſided pyramid. The ſpecific gravity of nitre according to Newton, is = 1.9, according to Muſchenbroek, = 1.901, and according to Haſſenfratz, = 1.9369:[b] the latter of theſe eſtimates ſeems to be the leaſt correct. It has a ſharp ſaline and cooling though diſagreeable taſte. When fully cryſtallized it is very brittle, and the larger priſmatic cryſtals if held in the warm hand, will crack acroſs with a very audible noiſe. It generally attracts a little moiſture on expoſure to the air, but this is probably to be attributed to the caſual mixture of a ſmall portion of deliqueſcent ſalt. With regard to the degree of ſolubility of nitre in water of different temperatures, there exiſt ſome contradictions that require to be cleared up: according to Bergman, this ſalt is ſoluble in ſeven times its weight of water at the uſual temperature, and in about its own weight of boiling water; from the experiments of Haſſenfratz however it appears that a hot ſaturated ſolution of nitre, after being cooled down to 61° Fahr. and remaining at this temperature 24 hours, holds nearly $\frac{1}{4}$ of its weight of ſalt, and at 54° Fahr. about $\frac{1}{6}$ of its weight: according to Beaumé,[c] 4 ounces of boiling water will take up 10 ounces of nitre when the ſolution is made in a matraſs, but if a baſon or any other open veſſel is made uſe of, a pellicle begins to form at the ſurface of the liquor when it contains water and ſalt in equal proportions. The following table of the ſpecific gravity and compoſition of ſolutions of nitre in water at 61° Fahr. has been conſtructed by Haſſenfratz.[d]

Sp. gr. of ſolution at 61° Fahr.	Proportion of Nitre in 100 parts of ſolution.
1.006	1
1.012	2
1.018	3
1.024	4
1.030	5
1.035	6
1.040	7
1.046	8
1.053	9
1.059	10
1.065	11
1.072	12
1.078	13
1.085	14
1.091	15
1.098	16
1.105	17
1.111	18
1.118	19
1.125	20

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[a] Obs. on Air, vol iii. p. 146.

[b] Ann. Ch. xxviii. p. 16.

[c] Chem. exper. i. p. 414.

[d] Ann. Ch. xxvii. p. 135.

Sp. gr. of ſolution at 61° Fahr.	Proportion of Nitre in 100 parts of ſolution.
1.132	21
1.138	22
1.145	23
1.152	24
1.158	25

If a ſaturated ſolution of nitre is boiled ſtrongly, and more eſpecially if the boiling temperature is raiſed by the addition of any deliqueſcent ſalt, a very notable proportion of the nitre is volatilized with the water, as will be mentioned more particularly in the latter part of this article.

Nitre is readily fuſible at a heat almoſt equal to that of melting zinc, or ſomewhat below ignition, and may be kept for a conſiderable time at this temperature without undergoing any change, except a ſlight loſs of weight from parting with its water of cryſtallization; a piece of charcoal may even be immerſed in it without producing any detonation. When poured out on any flat ſurface it preſently congeals into a white tranſlucent maſs, commonly known by the name of *cryſtal mineral*. If however the heat to which melted nitre is expoſed be greater than that requiſite for maintaining its liquidity, a decompoſition begins to take place; bubbles of gas are diſengaged, and by a high heat, continued as long as any air is extricated, the acid is entirely decompoſed, and nothing but the alkaline baſe of the ſalt remains behind; the gas that firſt comes over during this proceſs is tolerably pure oxygen, but the latter portions are largely mixed with azot. When this experiment is performed in an earthen crucible, the alkalization of the nitre takes place more ſpeedily, on account of the affinity of the potaſh for the ſilex and alumine of the crucible, hence alſo as the heat increaſes a conſiderable part of the acid is ſet at liberty in a ſtate of ſemi-decompoſition, which accounts for the red fumes of nitrous vapour obſerved on this occaſion by Beaumé. When the fuſion is not continued long enough for the total decompoſition of the nitre, the reſidue conſiſts of free alkali, and a variable proportion of nitrite of potaſh.

The decompoſition of nitre by heat is much more ſpeedy, if ſome inflammable ſubſtance be preſent: in this caſe a rapid diſengagement of light and heat takes place, accompanied by a loud hiſſing noiſe, which is called the *detonation of nitre*; the added inflammable matter combines with the greater part of the oxygen of the nitric acid, and is itſelf converted into an oxyd or acid; if the latter, it generally unites with the alkaline baſe of the nitre in proportion as its own acid is decompoſed or driven off. Thus if a few grains of ſulphur be projected on red-hot nitre the former immediately takes fire, burns rapidly with a reddiſh-purple flame, and is converted into ſulphuric and ſulphureous acid, at the expence of the nitric acid, which is more or leſs decompoſed; the ſulphureous acid mixed with nitrous vapour flies off, while the ſulphuric acid remains behind in combination with the diſengaged potaſh of the nitre, forming ſulphat of potaſh. When the quantity of ſulphur added is not ſufficient to effect a total decompoſition of the nitre, the reſult is a mixture of the two neutral ſalts, and was known among the old chemiſts by the name of *Glaſer's polychreſt ſalt*.

If inſtead of adding the ſulphur by ſmall parcels at a time to the nitre in fuſion, the two ingredients are carefully mixed together in the proportion of five or ſix parts of the former to one of the latter, and the ſurface be then touched with a hot iron or any other ignited body, the detonation is much ſlower than in the former caſe, the nitric acid appears to be entirely decompoſed, and a quantity of SULPHURIC ACID, much more than ſufficient to ſaturate the alkali of the nitre, is produced.

The detonation of nitre with charcoal is very rapid, whether the charcoal is added to the nitre brought previouſly to a ſtate of fuſion, or the two ingredients are mixed together by pulverization, and then thrown into a crucible or any other veſſel heated red-hot; an intenſe bluiſh flame is diſengaged, accompanied by great heat and a white vapour, the nitric acid diſappears, and the reſidual ſalt is ſub-carbonat of potaſh. The rationale of this proceſs is commonly thus explained: the charcoal combines with the oxygen of the nitric acid, and is itſelf converted into carbonic acid, of which a portion unites with the alkaline baſe of the nitre, while the reſt is volatilized together with the azot produced by the decompoſition of the nitric acid. From the experiments however of Mr. Davy[c] it appears, that the detonation of theſe two ſubſtances is by no means a proceſs of ſuch ſimplicity as is generally imagined. This able chemiſt having filled a glaſs tube with a mixture compoſed of 6 parts of nitre and 1 of charcoal, detonated it, and received the product in a jar inverted over mercury and containing a little water: after the operation the water was found to be ſufficiently acidulous to reſtore the colour of red cabbage juice that had been rendered green by an alkali, thus indicating the preſence of a little nitrous acid; but the ſame liquor when ſuperſaturated by cauſtic potaſh or quick-lime, gave out a very ſenſible odour of volatile alkali, hence it appears to have contained acidulous nitrat of ammonia. The gas produced by the detonation being mixed with the carbonic acid ſeparated by muriatic acid from the alkaline reſidue, was found to be compoſed of carbonic acid, nitrous gas, and azot, in the proportion by bulk of 20 of the firſt, 3 of the ſecond, and 7 of the third.

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[c] Reſearches, p. 44.

If the charcoal in the detonating compound inſtead of being $\frac{1}{7}$ is raiſed to $\frac{1}{5}$ of the maſs, no nitrous gas, and probably no nitrous acid is produced, which agrees with the obſervation of Macquer,[f] who expreſsly ſtates that when ſucceſſive portions of a mixture of nitre and charcoal are detonated in a diſtillatory apparatus, "nothing is found in the retort but the alkali which was the baſis of the nitre; and the liquor contained in the receiver has no acid taſte, does not redden the tincture of turnſol, makes no effervеſcence with alkaline matters, and is truly nothing but water which is ſometimes ſlightly alkaline." The preſence of ammonia in Mr. Davy's experiment may we think be ſatisfactorily accounted for by the decompoſition of the water of cryſtallization by the charcoal, and the combination of its hydrogenous baſe with the azot of the nitric acid.

Thoſe compound acids into which carbon enters as an eſſential conſtituent, decompoſe nitre with nearly the ſame energy as charcoal does: thus if equal parts of nitre and crude tartar are mixed together and ignited, a detonation takes place, the tartareous and nitric acids mutually decompoſe each other into carbonic acid and other gaſſeous products, and there remains behind ſub-carbonat of potaſh, being the alkaline baſe of both ſalts. The alkali thus produced was in much requeſt among the old chemiſts by whom it was named *white flux*, *extemporaneous alkali*, and *nitre fixed by tartar:* it is in no reſpect however different from purified pearlaſh if the nitre has been all decompoſed.

Moſt of the metals if reduced to filings or powder and mixed with nitre will produce a detonation at a red heat; the metal in a ſtate of high oxydation unites with the alkali, and the nitric acid is more or leſs compleatly decompoſed. Thoſe metals that are moſt inflammable produce the moſt violent detonation, ſuch are zinc, antimony, tin, iron and biſmuth.

The effect of pure hydrogen on nitre has not been examined, but thoſe readily-fuſible inflammable bodies into the compoſition of which it largely enters, are not capable of detonating with nitre except in exact proportion to the amount of carbon that they contain beyond what is requiſite for the production of carburetted hydrogen, or, in the words of Macquer, to whom the diſcovery belongs, "no detonation will happen till the inflammable matter be burnt and reduced to a coal; then the detonation commences, and is always proportionable to the quantity of coal produced by the inflammable matter." Thus if oil, fat, reſin, pitch, mineral tar, or camphor, are dropped upon ignited nitre, they burn with a large flame, but without producing thoſe violent jets of fire that charcoal does, or haſtening the decompoſition of the ſalt. If a combuſtible ſubſtance of this claſs, but conſiderably mingled with charcoal, as aſphaltum, be treated in the ſame manner, the carburetted hydrogen, as being the moſt inflammable, firſt burns off with a quiet flame, and then the remaining charcoal produces the uſual phenomena of detonation.

Nitre is entirely decompoſed by diſtillation at a moderate heat with ſulphuric acid, and at a higher temperature with phoſphoric, boracic, and arſenic acids; theſe combine with the alkali of the ſalt, while its acid paſſes over in the ſtate of vapour; a ſimilar effect is produced by ſilex or alumine, or a mixture of both, but the heat requiſite in this caſe being conſiderably higher than in the former a proportionably larger quantity of nitric acid is decompoſed during the proceſs. Strong muriatic acid will alſo in part decompoſe nitre, as we have already ſhewn in our account of that ſubſtance.

The only ſubſtance capable of decompoſing nitre ſo as to liberate its alkali, is cauſtic barytes, a quantity of each in fine powder being mixed together, and then moiſtened with a little water, re-act on each other and produce nitrat of barytes and cauſtic potaſh, of which the latter alone (if too much water is not uſed) remains in ſolution.

The exact analyſis of nitre is attended with many difficulties, in conſequence of which even the moſt able chemiſts vary materially in their accounts of its compoſition. Bergman found that 49 parts of potaſh when ſaturated with nitric acid afforded 100 of cryſtallized nitre. Hence he ſtates the proportions of this ſalt at

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[f] Chem. Dict. art. Clyſſus.

49	Potaſh
33	Nitric acid
18	Water
100	

According to Wenzel 100 parts of nitre contain

48.13	Potaſh
51.87	Acid and water
100.00	

But according to Kirwan 100 parts of cryſtallized nitre dried at 70° Fahr. are compoſed of

51.8	Potaſh
44	Acid
4.2	Water
100.0	

and this eſtimate being incidentally confirmed by other experiments of Berthollet and of Keir, is probably very near the truth.[g]

The uſes of nitre are very important. It is employed in prodigious quantities in the manufacture of gunpowder, and in all kinds of pyrotechnical compoſitions. It is the only ſalt from which nitric acid is habitually made, both in the large and ſmall way; it is alſo largely conſumed in the preparation of ſulphuric acid from the combination of ſulphur. When mixed with common ſalt it adds to the efficacy of this latter in preſerving animal fleſh from decay; it is employed by the glaſs-maker and the goldſmith, and is in conſtant uſe in the laboratory.

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We now proceed to treat of the natural hiſtory and manufacture of nitre, as carried on in various countries, but chiefly in France, where its production has been more an object of philoſophical inveſtigation than in any other country.

Nitre may be conſidered both as a natural and artificial product. Native nitre mineralogically ſpeaking, is a ſubſtance of very recent formation. It appears to occur in two different repoſitories: the firſt of theſe is limeſtone, and the ſecond vegetable ſoil. The calcareous repoſitory is either a peculiar variety of ſecondary floetz limeſtone, or calcareous tufa, or chalk, or indurated marl. In theſe rocks it occurs as a thin granular cruſt, or an effloreſcence of minute ſpicular cryſtals overſpreading the outſide, and particularly lining the inſide of the caverns both natural and artificial, with which theſe rocks abound. Hence probably is derived its ancient name ſaltpetre (*Sal petræ*, rock ſalt). Calcareous ſtrata containing nitre, are found in various parts of South America, in ſome diſtricts of France, in the county of Bamberg, and at Hamburg near Wurtzburg. But the moſt celebrated repoſitory of native nitre is the Pulo of Molfetta, in the province of Puglia, in the kingdom of Naples. The Pulo is a deep cavity in the form of an inverted cone, produced by the falling in of ſeveral large natural caverns, and communicating laterally with other caverns both natural and artificial, that yet remain entire. All the ſtrata in which theſe excavations occur are of hard ſecondary limeſtone, abounding with the remains of organized bodies. The whole of theſe caves at the time when the Abbé Fortis called the public attention to them, were lined with an effloreſcent cruſt of nitre more than an inch in thickneſs, which after being ſcraped off, was again renewed in the courſe of a few days in conſtant ſucceſſion. Thin fragments of ſtone were often falling down, being forced from their place by the cryſtallizations of nitre beneath them; the ſubſtance of the rock alſo to the depth of a foot or more from the ſurface, was richly impregnated with the ſalt which might be ſeparated by lixiviation; but ſpecimens taken from a greater depth ſeem to contain no nitre ready formed, at leaſt boiling water was incapable of diſſolving out any. It appears however from the teſtimony of Dolomieu, that a piece of this rock after lying for two months in a dry cabinet, became covered with a thin cruſt of nitre. Specimens of the nitrous cruſt from the Pulo have been analyſed both by Klaproth[h] and Pelletier,[i] and the reſults agree full as well as can be expected in the examination of a ſubſtance ſo liable to ſlight variations in its compoſition.

Klapr.		Pellet.	
425.5	—	407.5	Nitre
2.	—	——	Muriated potaſh
		26.7	Muriats
		20.8	Sulphats, ſoluble in cold water
254.5	—	96.7	Sulphat of lime.
304.	—	410.	Carbonat of lime
986.0	—	961.7	
14	—	38.3	Loſs
1000.	—	1000.	

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[g] Kirwan on Acids (Additional Obſer.) p. 70.

[h] Analyt. Eſſ. I. p. 273.

[i] Mem. de Chem. II. p. 477.

The ſecond repoſitory of native nitre is vegetable ſoil. It is aſſerted by ſome chemiſts, eſpecially thoſe who maintain that nitre is a product of vegetation, that all ſoils contain nitre in proportion to their fertility: this however is by no means the caſe: Mr. Beaumé lixiviated carefully 36 ſpecimens of fertile ſoil, and did not obtain a particle of nitre from any one of them.[k] There is no country in Europe the ſoil of which is ſo rich in this ſalt as Spain. It is aſſerted by Bowles that nearly a third of the uncultivated lands in the Eaſtern and Southern provinces of this kingdom afford it in abundance under the following ſimple management. The land is ploughed twice or thrice during the winter and ſpring, to the depth of three or four inches; it lies fallow the whole ſummer, and about the middle of the autumn the ſoil having been thus expoſed to the full action of the air, is carted off and lixiviated: the liquor is then boiled down in the uſual manner, and affords by cooling a quantity of nitre mixed with from 20 to 40 *per cent.* of common ſalt.

A conſiderable part of the ſoil in Lower Hungary is richly impregnated with nitre, and ſeveral of the wells and ſprings are incapable of being uſed as drink on account of their containing from $\frac{2}{3}$ to 4 *per cent.* of this ſalt.[l]

Many of the lands in India, eſpecially in the vallies of the great rivers, are exceedingly abundant in nitre. In the preſidency of Calcutta alone between 7 and 8000 tons are annually manufactured. Sometimes it covers the ſurface of the ſoil with a ſaline efflorеſcence, which being ſwept off is renewed every other day at particular ſeaſons of the year. The ſoil of thoſe lands in which it is leſs abundant is raked up into ſmall heaps, and mixed with the ſcrapings of roads and cattle-ſtalls, and after being expoſed for a certain time to the action of the air is lixiviated: the earthy reſidue is mixed with freſh earth, and after two years affords as large a produce of nitre as at firſt.

In many nitrous ſoils the acid which they contain is combined for the moſt part with lime inſtead of potaſh, ſo that the produce of real nitre which they afford by the uſual mode of treatment is very ſmall: long experience however has taught the nitre-makers in every country where theſe ſoils occur, to remedy this defect by the addition of wood-aſhes. The rationale of this, though wholly unknown to the greater number of thoſe who practiſe it, is ſufficiently obvious to the chemiſt; the carbonated alkali of the aſhes and the calcareous nitrat of the ſoil mutually decompoſe each other, and carbonated lime and nitrated potaſh is the reſult. Many of the nitrous ſoils in India require this alkaline addition, as well as thoſe of China and other parts of Aſia. Much of the nitrous ſoil in the Crimea and Ukraine alſo is of this deſcription: in appearance it reſembles common black vegetable mould, except that it is more unctuous to the touch, and is ſo light and of ſuch little coherence as to be converted to a looſe duſt by a few days of dry weather. Thoſe parts of the Crimea that have been long uncultivated, and eſpecially the artificial mounds that have ſerved for burial places and the ſites of towns, are ſelected by the nitre-makers. The ſoil being dug up is mixed with about $\frac{1}{5}$ by meaſure of wood-aſhes, and lixiviated in perforated caſks in the uſual way: the liquor thus produced, when concentrated by repeated lixiviations, is mixed with the mother water of a preceding cryſtallization, and boiled down for 24 hours, removing from time to time the common ſalt and muriated potaſh that ſeparates during the proceſs; it is now transferred while hot into ſhallow coolers, in order to cryſtallize, which it does in 24 hours more. The rough cryſtals being drained are again diſſolved in water, and the product of the ſecond cryſtallization is a nitre ſomewhat impure but yet in a fit ſtate for the market. Four hundred cubic feet of the mixture of earth and wood-aſhes afford 42 lbs of nitre of the firſt cryſtallization, which by the ſubſequent refining is reduced to 39 lbs.

Before the general uſe of gunpowder in war, the produce of native nitre was abundantly ſufficient to ſupply the European demand for this article; but when in conſequence of the univerſal adoption of fire-arms the conſumption of this ſalt was prodigiouſly increaſed, it became an important object for every nation, and eſpecially thoſe that were the leaſt commercial, to encourage by every method the domeſtic manufacture of nitre. Every kind of ſoil that had the leaſt reſemblance to the nitre ſoils of Spain and India, was examined by lixiviation, and by degrees it was aſcertained that the ſurface ſoil of farm-yards, of cattle-ſtalls, of cellars, of privies, and other places long expoſed to the vapours of putrefying animal matter, afforded, when mixed with wood-aſhes and lixiviated, a conſiderable quantity of nitre. It was alſo diſcovered that the plaiſter, mortar, and what is included under the general term brick-rubbiſh of old houſes, was capable of yielding this ſalt by a ſimilar treatment. In conſequence of this diſcovery all theſe ſubſtances were claimed by the crown in moſt of the countries of Europe, and granted to ſocieties of ſaltpetre-makers, incorporated for the purpoſe of ſupplying the public magazines of the country with this indiſpenſable commodity. England and Holland were ſoon able to ſupply themſelves at an eaſy rate with nitre, by means of their commercial connexions with India and China, and therefore attended only a very ſhort time to the domeſtic preparation of this ſalt. France, Germany, and the Northern ſtates of Europe on the other hand, importing but a ſmall quantity of nitre in proportion to their wants, have always encouraged its manufacture by every method in their power. In the former of theſe countries eſpecially, the privileges of the ſaltpetre-makers were ſo extenſive and ſo rigorouſly enforced, as to occaſion much petty tyranny and vexation, beſides operating as a direct diſcouragement to agriculture. Theſe manufacturing companies were allowed to take away without compenſation all the nitrous ſoils that they could diſcover: hence when a houſe was pulled down, ſuch part of the old materials and foundation ſoil as ſuited their purpoſe was ſelected from the reſt and carried off by them; they had alſo the right of digging up once a year the earthen floors of every out-houſe, and in ſome provinces even of the inhabited cottages: the farmer's yards were ſubject to the like troubleſome viſitations, by which he was deprived of a conſiderable quantity of his beſt manure; and every pariſh or diſtrict was obliged beſides to furniſh a certain amount of wood-aſhes. Theſe terrible means of annoyance were placed by the crown in the hands of the farmers general, and by them were entruſted to inferior agents, more diſpoſed to exerciſe them ſo as to obtain from thoſe in their power a pecuniary compoſition, than to exert their privileges for the public advantage; the conſequence of which was that notwithſtanding the trouble and extortion by which individuals were thus ſeverely haraſſed, the annual produce of nitre at the acceſſion of Turgot to the miniſtry, ſcarcely exceeded one half of what it had amounted to half a century before. An important reform however was introduced by this able ſtateſman, the privilege of digging up the floors and cellars of inhabited houſes was aboliſhed, the requiſitions of fluel and wood-aſhes were reſtrained, and the adminiſtration of this department was taken from the farmers general, and entruſted to a particular commiſſion, of which Lavoiſier and Clouet were leading members; a conſiderable ſum of money was placed at the diſpoſal of the Royal Academy of Sciences, to be diſtributed as prizes by this body to the authors of the beſt memoirs on the preparation of ſaltpetre, in conſequence of which various important changes took place in the management and conſtruction of artificial nitre-beds, and the refining of their produce. By theſe means the yearly amount of nitre made in France was increaſed during the period from 1775 to 1785, from 1,800,000 lbs. to 3,500,000 lbs. Four years after this period the Revolution war commenced, for the ſupply of which a prodigious quantity of gunpowder was demanded, while all the requiſite nitre was obliged to be drawn from domeſtic ſupplies. To meet this exigency the knowledge and perſonal ſuperintendance of the ableſt chemiſts of Paris was directed to this important object, and in the ſpace of a very few years the produce of nitre was more than quadrupled, and a ſimplicity and expedition introduced into the refineries of this ſalt, that ſeem to have brought its manufacture nearly to perfection.

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[k] Mem. de Scavans Etrang. XI. p. 382.

[l] Ruckert, Journ. des Mines, No. 2, p. 12.

In our account of nitric acid we have ſhown that the component parts of this ſubſtance are azot and oxygen, we have alſo ſhown in another place that animal matters in general contain a large quantity of azot combined in various proportions with hydrogen, carbon and other ſubſtances. When the decompoſition of animal matter by means of the putrefactive fermentation takes place, its elements enter into new combinations with each other and for the moſt part aſſume the gaſeous form. Now although azot like ſeveral other bodies when it has compleatly acquired the ſtate of elaſtic fluidity is but little diſpoſed to combine with oxygen at the uſual atmoſpheric temperature, yet when in its naſcent ſtate and particularly when mixed at the ſame time with eaſily combuſtible ſubſtances it unites with oxygen without much difficulty. Hence it is obvious how nitrous acid or more probably nitrous vapour is produced by the contact of atmoſpheric air and putrid gas. But the acid is produced ſlowly, and in proportion as it forms will fly off together with the other volatile ingredients, except it meets with an alkaline baſe to combine with into a neutral ſalt. It might ſeem, *a priori*, a matter of perfect indifference, as far as the mere formation and detenſion of nitrous acid is concerned, whether one alkaline ſubſtance or another was employed for this purpoſe, but experiment has ſhown, as we ſhall detail more at large preſently, that the proper fixed alkalies, whether in a mild or cauſtic ſtate are by no means ſo efficacious as carbonat of lime. Thus it appears that three conditions are requiſite for the production of nitrated lime (from which by the ſubſequent addition of carbonated potaſh common nitre is readily obtained) viz. animal matter in a ſtate of decompoſition, atmoſpheric air, or rather the oxygenous part of it, and carbonated lime.

The firſt propoſal for the conſtruction of artificial nitre beds came from Glauber. This able chemiſt reflecting on the circumſtance that earth which had been long expoſed to exhalations from the dung and urine of ſheep and other animals, or in which animal bodies had been buried was capable of affording nitre by lixiviation, concluded that this ſalt was contained in animal matter: but finding that various animal fluids ſuch as urine and blood, afforded no nitre when recent, he was induced to try the effect of putrefaction on them: for this purpoſe he filled an open veſſel with blood, and expoſed it to ſpontaneous decompoſition till nothing remained of it but a looſe earth: from this by lixiviation he obtained a portion of nitre, hence he concludes that the ſalts contained in recent animal matter are in an inert or as he calls it a dead ſtate, till by long expoſure to the air and fermentation they acquire from it a vital ſpirit.[m] From the nitrous efflorefcences on the plaiſter of cellar walls he inferred that the ſaline baſe of nitre was alſo contained in certain earths; and becauſe that part of the plaiſter in immediate contact with the bricks, and therefore excluded from the air, afforded no nitre by lixiviation, he drew the ſame concluſion as in the former caſe reſpecting the *vivifying* influence of the air in the formation of nitre. It being a matter of common notoriety that earth when long impregnated with the lees of wine became rich in nitre, this circumſtance together with other collateral arguments induced him to infer the preſence of nitre in vegetables alſo. In purſuance of this theory he propoſes the following plan for the formation of nitre.[n] Let a large ſquare wooden vat be made open at top, and with a perforated falſe bottom placed a few inches above the real bottom, and between the two bottoms let a pipe with a ſtop cock be inſerted ſo as to diſcharge any liquor into a ſhallow open reſervoir ſunk into the ground juſt in the front of the vat: on the oppoſite ſide of the reſervoir let another vat ſimilar to that already deſcribed be placed, and, to compleat the apparatus, let a pump be fixed in the reſervoir by which its contents may be transferred to either of the vats that the workman chooſes. Every thing being compleat let the vats be filled with horſes', cows', or ſheeps' dung mixed with leaves or any dry vegetables: then draw a weak alkaline ley from quicklime and woodaſhes and pour it into one of the vats till it ſtands a finger's breadth above the other ingredients. In about 12 hours time turn the cock and let the liquor drain into the reſervoir, whence it is to be pumped again into the other vat, and after 12 hours more returned into the reſervoir. In the ſpace of a few days the contents of the vats will heat and ferment ſtrongly: no further care is required till the decline of the fermentation, which may be known by the ceſſation of the ſteam: the materials are then to be again drenched with the liquor in the reſervoir for 12 hours, and when this is again diſcharged the fermenation will recommence. This method being purſued for ten or twelve months, (taking care to keep the vats filled with freſh portions of leaves and dung as the maſs ſubſides) both the liquor and the contents of the vats will be found to be very rich in nitre.

The above method of Glauber's deſerves notice as the firſt attempt at the artificial manufacture of nitre, although there is little doubt that its ſucceſs is greatly exaggerated, as is but too much the cuſtom of this author. Another method propoſed by the ſame chemiſt and the ſucceſs of which is better authenticated is the following. Conſtruct a vault of frame work of any dimenſions and line it to the thickneſs of three or four inches with plaiſter compoſed of the following materials, viz. one part of quicklime, one of woodaſhes, and two of cow's or horſe' dung with a ſufficient quantity of urine to work it up to a proper conſiſtence. This plaiſter being carefully applied is to be dried by a gentle fire to be made under the vault, a ſecond coating of the ſame materials is then to be put on, and thus by alternate drying and plaiſtering the vault is to be made two or three feet thick. Being now ſufficiently ſtrong the wooden framing may be removed. The plaiſter in proportion as it dries is to be reſtored to a proper ſtate of moiſture by the application of urine, and in the ſpace of a few months, more or leſs according to the warmth of the air and other circumſtances, the whole inſide of the vault will be covered with nitrous effloreſcences: by degrees the plaiſter will be impregnated with nitre through its whole ſubſtance, at which time the vault being broken down and its materials being duly lixiviated, a large quantity of nitre will be obtained. This method was adopted in many parts of Germany with reaſonable ſucceſs, but requiring much manual labour was at length abandoned for more economical proceſſes.

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[m] German. Proſperit. part I. p. 103

[n] Ditto, part III. p. 7.

In direct oppoſition to the inſtructions on this ſubject by Glauber who had clearly ſhown the abſolute neceſſity of the preſence of air to the formation of nitre, ſeveral very large experiments were made, chiefly in Sweden and Germany to prepare this ſalt by filling large trenches with animal and vegetable refuſe of various kinds mixed with quicklime and wood aſhes and duly watered with urine. But though all other circumſtances, were tolerably favourable the excluſion of air from the greater part of the maſs ſo delayed the production of nitre, that after the expiration of 20 years a ſmaller quantity of this ſalt was thus obtained than is yielded by the ſame materials in two or three years when the air is freely admitted to them. Attempts were made to remedy theſe defects by the inſertion of pipes and air ſhafts, but with little ſucceſs compared to the trouble and expence; ſo that at length, inſtructed by experience, the Swedes adopted that mode, which with a few modifications they ſtill retain, and the advantages of which are daily more and more apparent. Upon a ſquare floor of brick or ſtone, is laid a bed a few inches thick compoſed of woodaſhes, lime, and mellow vegetable earth moiſtened with urine, and the mother water obtained in the refining of nitre: upon this is placed a layer of ſtraw or old thatch, then another of the compoſition, and ſo on alternately till a pyramid 8 or 9 feet high is conſtructed. In order to preſerve theſe piles from the rain and ſnow which would waſh out the ſalt as faſt as it formed, a number of ſtout poles are ſtuck in the ground all round the floor, the tops of which are tied together, and their interſtices carefully cloſed with intertwiſted twigs, thus excluding the rain, but admitting the air. Theſe pyramids are watered from time to time with putrid urine, and in about a year ſaline effloreſcences begin to appear on their ſurface: ſhortly after, the nitre thus generated is ſwept off, and the piles then yield regular crops of this ſubſtance every week or ten days, except during froſty weather, for about nine years. At the expiration of this period the effloreſcence ceaſes, and the nitre yet remaining in the pile is obtained by lixiviation: the inſoluble reſidue is an excellent manure and much in requeſt for flax and hemp. In Pruſſia, nitre is obtained from mud walls compoſed of loamy earth, night ſoil, mud from ponds, ſtable litter, and any other vegetable or animal ſubſtances: theſe being mixed together and tempered to the conſiſtence of ſtiff mortar by urine and dunghill drainings, are raiſed into walls four feet high and about two feet thick, and topped with a ſlight coping of thatch in order to ſhoot off the rain: in proceſs of time the ſtraw and other vegetables which the walls contain decay, by which it is rendered more porous and the air gets admiſſion more or leſs to its interior ſubſtance. Many however are the objections to this method of preparing nitre. In the firſt place the labour required for the conſtruction of theſe walls is very conſiderable: ſecondly, the clayey loam which is neceſſary to give the maſs a due conſiſtence for the formation of walls, prevents it from being ſufficiently porous even after the ſtraw, &c. has decayed: thirdly, there is ſeldom a proper quantity of calcareous matter, ſo that much of the nitrous acid flies off for want of a fit baſe to detain it: and fourthly, the very imperfect protection from the weather which theſe walls receive from their thatch coping, ſubjects a conſiderable quantity of the ſalt when formed to be waſhed out by the rain and thus loſt. For theſe reaſons it is ſeldom worth while to lixiviate this earth oftener than once in about ſix or eight years, and even then the produce is very ſcanty.

In France the nitre-beds are compoſed of nitrous earth from farm-yards, ſtables, &c. of ſtreet ſweepings, of mild calcareous earth, ſuch as old mortar or plaiſter, chalk, tufa, or the ſweepings of roads paved with limeſtone; of animal matter, ſuch as night-ſoil, blood, refuſe from the ſkinners and tanners, bones and other offal; of vegetable matter, ſuch as ſtraw and ſtable litter, leaves, ſawduſt, ſpent tanner's bark, &c. Theſe are all mixed in ſomewhat caſual proportions, care being only taken that a ſufficient quantity of calcareous matter is preſent; they are laid as lightly as poſſible in long beds or pyramids under covered roofs to protect them from the weather, and are kept duly moiſtened with putrid water or urine: by this management they yield every other year by lixiviation a conſiderable quantity of nitrated lime, which by the addition of woodaſhes or potaſh is converted into true nitre. The circumſtance in which the French nitre beds differ principally from thoſe of Sweden and Germany is that they ſcarcely ever contain woodaſhes, the requiſite portion of alkali being added in a ſubſequent part of the manufacture.

The proportion of nitre afforded by theſe artificial beds it is not eaſy to aſcertain. In France, where the cuſtom is to lixiviate once in two years, the produce may be eſtimated at from 7 to 12 ounces of nitre from 100 lbs. of materials: of this about half is nitrat of potaſh, and the reſt nitrat of lime, requiring therefore the addition of potaſh to convert it into true nitre.

Concerning the theory of nitrification much has been written, but with the exception of an admirable memoir by M. Thouvenel, to little purpoſe. The chemiſts of the modern ſchool having diſcovered that nitric acid is compoſed of oxygen and azot, and that animal matters abound in condenſed azot, content themſelves with ſaying that the azot as it is evolved by the progreſs of putrefaction combines with the oxygenous part of the air, and thus forms nitric acid, which is prevented from eſcaping by the lime and other alkaline baſes with which it is in contact. This however from the little hitherto known on the ſubject appears to be a very imperfect repreſentation of the matter; we ſhall therefore proceed to detail the principal reſults of M. Thouvenel's experiments, which, imperfect as they are, throw more light on this curious and important ſubject than any others with which we are acquainted.*

Several open veſſels containing each three lbs. of pure and well waſhed chalk moiſtened with diſtilled water, were for the ſpace of ſeven or eight months expoſed to the putrid vapours of privies, cellars and priſons, being then lixiviated they afforded from 50 to 90 grs. of nitre each, of which the principal part was nitrat of lime but mixed in general with a little nitrat of potaſh. From other ſimilar experiments M. Thouvenel aſcertained that in cloſe confined ſituations where there was hardly any circulation of air, and on the other hand that in places where the external air paſſed in a free current, the production of nitre was by no means ſo copious as where the putrid fumes remained for a long time in contact with the chalk, and were only occaſionally diluted with atmoſpheric air. In thoſe places moſt favourable to the generation of nitre were expoſed together with the veſſels containing chalk, others with a like quantity of quicklime, with magneſia both mild and cauſtic, with earth of alum and with the fixed alkalies both mild and cauſtic. They were all examined after the expiration of 8 months: the ſaline contents of the chalk we have juſt mentioned; the quicklime, the cauſtic and mild magneſia afforded from 6 to 7 grs. of earthy nitrat mixed with a little ammoniacal nitrat; the earth of alum yielded a ſtill ſmaller proportion of nitrat, and the fixed alkalies none at all. The reſults of theſe experiments being aſcertained, another ſeries was undertaken and conducted in the following manner. An earthen cucurbit was fitted to a very large receiver of the ſame materials pierced with a few ſmall holes ſo as to allow of a partial communication between its contents and the outer air: in the cucurbit was put ſome putrid blood, and in the receiver were placed open veſſels containing a few ounces of lime, magneſia, earth of alum, and the fixed alkalies both mild and calcined: 21 other receivers furniſhed in the ſame manner were connected with cucurbits charged with various putreſcent mixtures. The gas as it was diſengaged from the materials in the cucurbit paſſed into the receiver mixing with the atmoſpherical air, and ſurrounding the incloſed earth and alkalies. After this proceſs had been continued for a year or more the contents of the receivers were examined; in all of them the chalk was found to contain nitrat of lime but varying in proportion from one to 5 grains per oz. The quicklime, the magneſia and earth of alum in moſt of the experiments had acquired no nitric acid, but in ſome a little earthy nitrat was formed. The fixed alkalies, as in the former experiments, had acquired no nitric acid whatever. It was further obſerved that although the chalk in moſt of the experiments ſhowed ſigns of nitrification in about a month's time and proceeded rapidly for the firſt three months, yet after this period the progreſs was very ſlow, no doubt becauſe the oxygen of the atmoſpheric air originally contained in the receivers having been conſumed, the gradual pouring in of putrid gas from the cucurbit almoſt entirely preventing the external air from entering through the ſmall holes that had been drilled for this purpoſe.

It appearing from the above experiments that the fixed alkalies and the alkaline earths themſelves when cauſtic are very little capable of abſorbing nitric acid from a mixture of putrid gas and atmoſpheric air, M. Thouvenel was induced to try whether this was owing to any change produced on the putrid gas by theſe bodies. For this purpoſe having charged a retort with putrefying materials, he connected with it three receivers in the manner of Woulfe bottles, the laſt of which terminated in a tube communicating with a pneumatic apparatus. Four different ſets of this apparatus were employed at the ſame time. In the firſt of theſe, the two receivers neareſt the retort were charged with four ounces of chalk diffuſed in diſtilled water, while the third receiver contained a ſolution of cauſtic potaſh. In the ſecond ſet the two firſt receivers contained diſtilled water, and the laſt was charged with the waſhed chalk. In the third ſet the two firſt receivers contained limewater; and in the fourth ſet a ſolution of cauſtic potaſh, the third receiver in both caſes holding the chalk. They were all equally expoſed to the ſame temperature, namely, from 74° to 80° Fahr. for ſix months, and the changes which their contents had undergone were then examined.

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* Mem. Etrang de l'Acad. des Sciences xi. p. 110.

The chalk in the firſt apparatus afforded 26 grs. of nitrat of lime mixed with a little nitrat of ammonia; the potaſh in the third receiver had become ſaturated with carbonic acid and had partly cryſtallized on the ſide of the receiver, but contained no nitre.

In the ſecond apparatus the water of the two firſt receivers had acquired a very putrid ſmell from the gas which had paſſed through it, and contained a little ammonia but afforded no nitrous ſalt on evaporation: the chalk in the third receiver afforded by lixiviation no more than 4 grains of nitrated lime.

In the third apparatus the lime water had depoſited its earth in the ſtate of carbonat, and the ſupernatant fluid had a ſtrong odour reſembling ammonia and putrid garlic: by evaporation it yielded 5 or 6 grains of nitrated ammonia. The chalk in the third receiver gave only a ſlight trace of nitrat of lime.

In the fourth apparatus the potaſh was cryſtallized but contained no nitre: with ſulphuric acid it effervеſced ſtrongly, giving out a very pungent and highly fetid gas: the chalk in the third receiver gave no indications whatever of the preſence of any nitrous ſalt.

The gas remaining in the receivers and collected in the pneumatic apparatus was in all the four experiments found to be ſlightly inflammable, although when riſing from the putrefying materials it extinguiſhed a taper immerſed in it. This putrid inflammable gas was incapable by itſelf of nitrifying chalk, but when mixed with waſhed atmoſpheric air, carbonic acid ſoon made its appearance, and then the gas became capable of impregnating chalk with nitrous acid as at firſt.

The above experiments were undertaken when pneumatic chemiſtry had as yet made but little progreſs, and therefore the deductions from them are by no means equivalent to the labour and time employed in carrying them on: it appears however that we may legitimately draw the following concluſions. In the firſt place the formation of nitric acid from animal matter in putrefaction, is not owing to atmoſpheric air being preſented to the azot when in a naſcent ſtate, for this change takes place after the azot and other gazefiable ſubſtances have actually aſſumed the elaſtic form. Secondly, the elements of the putrid gas are carbonic acid, azot, hydrogen and carbon, not mixed but combined together though weakly: this combination is in part deſtroyed by mere waſhing in water, but more compleatly by the action of thoſe alkaline baſes that are not compleatly ſaturated with carbonic acid; when the carbonic acid is abſtracted, the further decompoſition of this gas by atmoſpheric air tends more to the production of ammonia and carbonic acid than of nitric acid. Waſhed chalk after being thus nitrified often contains a little nitrat of potaſh as well as nitrated lime: it does not however hence neceſſarily follow that potaſh is alſo a product of putrefaction; for it may poſſibly pre-exiſt in the chalk in a ſtate inſoluble in water, as it does in leucite, in the alum ore of La Tolfa, and other minerals. The important practical concluſion to be deduced from theſe experiments is that the only alkaline ſubſtance to be admitted in the compoſition of nitre beds is mild calcareous earth.

Chalk however is not only capable of being nitrified by expoſure to the combined action of atmoſpheric air and putrid gas, but alſo by means of the atmoſpheric air alone. On this ſubject there are ſome experiments by Lavoiſier and Clouet, much to the purpoſe.[c] The village of Roche Guyon on the Seine, is ſituated on a ridge of chalk, which having the character of nitrifying ſpontaneouſly by expoſure to the air, was on this account viſited and particularly examined by the able chemiſts juſt mentioned. In order to aſcertain whether this chalk before the action of the air contained any nitrous ſalt, ſelection was made of a part of the rock which had recently been laid bare by the falling down of a large maſs. In this newly-expoſed face of rock, a gallery had been driven, of which the further extremity had been excavated only two or three days before. In order to render the experiment as unexceptionable as poſſible, about a foot more of chalk was removed from the extremity of the gallery, after which a ſpecimen of the weight of 12½ lbs. was dug out, and ſubjected to lixiviation: by evaporation of the fluid there were depoſited 4 grains of muriated ſoda; and the ſmall reſidue of mother water afforded by the addition of carbonated potaſh 53 grains more of ſalt, which appeared to be muriat of potaſh, with perhaps a ſlight admixture of nitre, for although it did not detonate in the ſmalleſt degree with charcoal, yet by ſulphuric acid it gave out acid fumes, in which the odour of nitro-muriatic acid was juſt perceptible.

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[c] Mem. Etrang. de l'Acad. des Sci. xi. p. 503.

Hence 100 French lbs. of this chalk afford

		gros.	grains.
without Potaſh	Muriat of ſoda	0	32
with Potaſh	Muriat of Potaſh and a little nitre	5	64
		6	24

A ſimilar ſpecimen was taken with the ſame precautions from an adjoining gallery and lixiviated, the ſaline contents of which calculated on 100 lbs. amounted to

		gros.	grains.
without Potaſh	Selenite in ſmall quantity Mother water, which gave		
with Potaſh	Impure nitre	0	68½
	Muriat of potaſh	1	38
		2	34½

Another ſpecimen of chalk, taken from near the ſummit of a rock after having removed the ſurface to the depth of about two feet, afforded by lixiviation from 100 lbs.

		oz.	gros.	grains.
without Potaſh	A little ſelenite Mother water, which gave			
with Potaſh	Nitre	1	2	24
	Muriated potaſh	0	1	10½
		1	3	34½

A ſpecimen of chalk taken from the middle of a rock, after having removed the ſurface to the depth of two feet, afforded from 100 lbs.

		oz.	gros.	grains.
without Potaſh	A little ſelenite Mother water, which gave			
with Potaſh	Nitre	5	5	19½
	Muriat of potaſh	0	1	70
		5	7	17½

A ſhallow cave that had been dug out of the chalk rock a conſiderable time before, was obſerved to be lined with ſaline effloreſcences: after the outer ſurface had been removed to the depth of three inches, a ſpecimen was taken, which afforded from 100 lbs.

		lbs.	oz.	gros.	grains.
without Potaſh	Nitre	0	10	1	52½
	Mother water, which gave				
with Potaſh	Nitre	0	10	1	52½
		1	4	3	33

The effloreſced ſurface to the depth of three inches, of the ſame cave, afforded

		lbs.	oz.	gros.	grains.
without Potaſh	Nitre - - - - - - - -	1	5	7	31
	Mother water, which gave				
with Potaſh	Nitre - - - - - - - -	3	1	3	24
	Muriat of Potaſh - - -	0	12	6	66
		5	4	1	49

A ſpecimen from another ſhallow cave, after the outer ſurface to the depth of between three and four inches had been removed, afforded from 100 lbs.

		lbs.	oz.	gros.	grains.
without Potaſh	Nitre - - - - - - - -	0	8	0	0
	Mother water, which gave				
with Potaſh	Nitre - - - - - - - -	1	9	4	8
	Muriat of potaſh - - -	0	5	4	51½
		2	7	0	59½

Hence it appears that the chalk compoſing theſe rocks, though perhaps not abſolutely and entirely deſtitute of nitric acid even at their centre, is much more abundant in this ſubſtance in proportion as it is ſituated near their ſurface, and that the perfect nitre or nitrat of potaſh is only found near the ſurface of the chalk: a circumſtance which ſeems to ſhow that both the acid and alkali have been either depoſited from the air, or formed by the contact of this latter with the chalk. In confirmation of this deduction may be mentioned an experiment by the Duc de la Rochefoucault, who lixiviated a conſiderable quantity of chalk, ſo as to diſſolve out its ſaline contents, and then expoſed it to the action of the air for fourteen months, during which period it had acquired not only nitric acid but potaſh, ſince the liquor of the ſecond lixiviation depoſited by evaporation a little nitre, and afterwards a conſiderable quantity more on the addition of potaſh. Theſe facts having never been called in queſtion, the next inquiry that occurs is whether the atmoſphere furniſhes the entire nitric acid or only one of the conſtituent parts of it? That this latter is the caſe might be inferred from the frequent occurrence of organic remains and impreſſions in chalk, whence this mineral may be ſuppoſed to be by no means deſtitute of animal matter. Againſt this however there may be alleged a direct experiment by M. Thouvenel, who on expoſing ſome waſhed chalk for ſix or ſeven months to a portion of atmoſpheric air confined in a large receiver, and previouſly well *waſhed* in diſtilled water, found that not an atom of nitrat of lime was generated; while in a ſimilar experiment in which waſhed chalk was expoſed to *unwaſhed* air, a very ſenſible quantity of nitrated lime was produced. Now the waſhing could not ſeparate the azot or oxygen, though it might and no doubt would take away any nitric acid ready formed, or any nitrous ſalt that might be contained in the atmoſphere. It is obſerved of theſe chalk rocks that thoſe parts that are adjacent to inhabited buildings yield a greater proportion of nitrat of *potaſh* than thoſe which are at a diſtance from houſes; a circumſtance that ſeems to point out a probable ſource of the alkali without ſuppoſing it to be generated either in the air or chalk. It is well known that the common fuel in France is wood, therefore the air in the vicinity of houſes muſt be more or leſs impregnated with pyroligneous acid contained in the wood ſmoke; but the acid vapour that flies off in the common method of preparing charcoal (and which is no other than pyroligneous acid) when collected in a proper apparatus condenſes into a ſour liquid from which by gentle evaporation a black reſidue is procured that yields by incineration a large proportion of potaſh, as we have ſhewn in our account of that ſubſtance, in the article CARBONAT OF POTASH.

It only remains to give an account of the extraction of nitre from the earths in which it is contained, and of the purification of this ſalt.

The firſt thing is to aſſay the earth. This is done by lixiviating a few pounds of it, and adding to the liquor thus obtained as much of a ſolution of common potaſh of a known ſtrength, as is ſufficient to decompoſe all the earthy ſalts. From this aſſay the quantity of alkali required is eaſily calculated.

The next proceſs is the lixiviation; which is performed in the following manner. Several cart-loads of nitrous earth are mixed as accurately as poſſible with the requiſite quantity of alkali, either in the form of wood-aſhes or pulverized potaſh. Several large caſks with perforated falſe bottoms are then filled with the prepared earth laid on very lightly; after which as much river water is poured in as the veſſels will hold. In two or three hours time the cock at the bottom of each caſk is turned, and the liquor is allowed to drain out during the remainder of the day. The caſks of a ſecond ſeries charged with earth as before are now filled up with the firſt lixivium, and after ſtanding for a few hours the liquor thus concentrated is drawn off in the manner juſt deſcribed. By a ſimilar proceſs on the third day a lixivium thrice as ſtrong as the firſt is obtained, which is now ſufficiently concentrated to be boiled down. The contents of each ſeries of caſks are lixiviated twice more, and the weak ſolutions thus obtained are employed inſtead of water in the firſt and ſecond lixiviations of freſh parcels of earth.

The boiling down and evaporation next ſucceeds. The lixivium, containing nitrat of potaſh, the muriats of potaſh and ſoda, with probably a few other ſalts, and various earthy and other impurities, is put into a large boiler like a ſalt-pan, and heated nearly to ebullition; it is then clarified by the addition of bullock's blood, or a ſolution of glue, the impurities as they appear on the ſurface being carefully ſkimmed off: when no more froth riſes of itſelf a little lime-water is added, which coagulates the remainder of the blood and glue, and thus compleats the clarification. It is now boiled for ſeveral hours, and the muriats of potaſh and ſoda as they depoſit are withdrawn by a perforated ladle. When the liquor is ſo concentrated that a few drops cryſtallize readily on being dropped on a cold iron, it is laded out into a vat, where it remains half an hour to depoſit the common ſalt and impurities ſtill floating in it: hence it is transferred to large wooden or metallic cryſtallizing baſons, where it remains cloſe covered up during from three to ſix days, according to the temperature of the air; at the expiration of this period the fluid mother water is poured out and returned to the nitre bed, and the ſalt depoſited in a confuſed cryſtalline maſs of an opake dirty white, is broken to pieces and ſet to drain, after which it is brought to market or delivered in to the government ſtores, as rough nitre or nitre of the firſt boiling.

In order to refine the rough nitre, the ancient practice was to ſubject it to two more ſucceſſive boilings and cryſtallizations; by this method however a very conſiderable proportion of the nitre was left in the mother waters, no inconſiderable ſhare was volatilized by the heat required for evaporating the ſolution when it had nearly acquired the due degree of concentration, and beſides a great expence both of time and fuel was incurred. The modern method of refining this ſalt was invented in France a few years ago, and is now conſidered as brought nearly to perfection. It is thus effected:

The rough nitre is broken to ſmall fragments by wooden mallets, and is then put into a wooden tub with 20 *per cent.* by weight of cold water; in this ſtate it remains for ſix or ſeven hours, being occaſionally well ſtirred up, that the water may have free acceſs to every part. The water is now let out by a hole at the bottom of the veſſel, and carries with it in ſolution all the deliqueſcent ſalts, and the greateſt part of the muriats of ſoda and potaſh, together with ſome nitre. When the whole of the liquor is drained off 10 *per cent.* more of water is added, and well mixed with the nitre for an hour's time, when it is diſcharged in the ſame manner as the firſt. Laſtly, 5 *per cent.* of water is poured in and run off again almoſt immediately after. The nitre thus waſhed, after being well drained, is put into a boiler with half its weight of water, and boiled till a pellicle forms on its ſurface; the liquor is then diſcharged into a large leaden cooler, and ſtirred about with rakes, till it is quite cold, by which manipulation the ſalt is depoſited in ſmall cryſtalline needles. It is now taken out of the liquor with a perforated ladle and well drained: after which it is waſhed with 5 *per cent.* of cold water, and again drained: being then ſpread out on a large table it dries in a few hours, and is laſtly heated over a fire in large baſons for two or three hours, at a temperature not exceeding 120° Fahr. taking care to ſtir it all the while; by this treatment it is perfectly purified and brought to the conſiſtence of fine ſand, and is now ready to be manufactured into gunpowder.

NITRAT OF SODA. Cubic or Rhomboidal Nitre.

This ſalt cryſtallizes in rhomboids or oblique quadrilateral priſms. Its flavour is ſimilar to that of common nitre, except that it is ſomewhat more bitter. It does not appear to occur native, but may readily be prepared by ſaturating nitric acid with carbonated ſoda and then evaporating the ſolution to a pellicle: the cryſtals are depoſited as the liquor cools.

When placed on a hot coal it firſt ſlightly decrepitates and is then decompoſed like common nitre, only with not ſo vigorous a detonation. By expoſure to the air it becomes ſoft and moiſt, without however abſolutely deliquiating.

It is ſoluble by thrice its weight of cold water, and in leſs than its weight of boiling water. It is decompoſed by the ſulphuric and other acids with the ſame phenomena as common nitre; it is alſo decompoſed by potaſh and barytes, cauſtic ſoda being liberated.

It is compoſed according to Kirwan of

53.21	Nitric acid
40.58	Soda
6.21	Water
100.	

Nitrat of ſoda is not applied to any uſe.

Nitrat of Ammonia. *Nitrum Flammans* of the older chemiſts.

This ſalt is ſeldom if ever found native, and is produced in the laboratory by ſaturating dilute nitric acid by carbonat of ammonia, and evaporating. If the evaporating heat does not exceed 100°, the liquor on cooling ſhoots into tranſparent cryſtals in the ſhape of ſix-ſided priſms, terminated by long ſix-ſided pyramids. But if evaporated at the heat of boiling water, it yields on cooling thin fibrous cryſtals, or if the evaporation be carried nearly to dryneſs, the whole concretes into a compact ſhapeleſs maſs.

Mr. Davy[a] infers theſe three varieties of nitrat of ammonia to be compoſed as follows: 200 grains of ſolution of pure ammonia containing 50.5 grains of alkali ſaturated 385.5 grains of nitric acid of 1306 ſp. gr. containing 190 grains of real acid, eſtimated in the way mentioned under that article. This mixture evaporated at 212° gave 254 grains of fibrous nitrat of ammonia. But from comparing the ſpecific gravity of the mixture before evaporation with that of a ſolution of another equal portion of the fibrous ſalt, it was found that 8 grains of the ſalt were diſſipated during the evaporation. The quantity of water in the 254+8 grains of the ſalt, was 21.5 grains, and hence 100 parts of the fibrous ſalt are compoſed of about 72.5 nitric acid, 19.3 ammonia, and 8.2 water.

The priſmatic ſalt (or that produced by gentle evaporation at a heat not exceeding 100°) is compoſed of about 69.5 *per cent.* of acid, 18.4 of ammonia, and 12.1 of water.

The other variety, the compact ſalt made by evaporation to dryneſs at a heat not exceeding 300° contains according to this able chemiſt 74.5 of acid, 19.8 of alkali, and 5.7 of water. Some of the ſalt is diſſipated during evaporation.

In theſe three varieties the quantity of alkali bears nearly the ſame proportion to the acid, and the difference is chiefly in the water of cryſtallization. During evaporation of the ſolution at a heat below 100° ſcarcely any loſs of ſalt is detected; at 212° the loſs is about 3 or 4 grains *per cent.* and at the boiling point of the ſaturated ſolution (which is many degrees higher) the loſs is about 4 to 6 grains *per cent.*

This ſalt may alſo be made by the decompoſition of ſulphat of ammonia by nitre. Nitrat of ammonia and ſulphat of potaſh are formed, and if no more nitre be added than is ſufficient for the decompoſition, a judicious evaporation and cryſtallization, two or three times repeated, will ſeparate theſe two ſalts almoſt entirely. Mr. Davy eſtimates that 100 grains of ſulphat of ammonia require about 134 grains of nitre, and yield 91 grains of compact nitrat of ammonia.

This ſalt is deliqueſcent in all its forms, and is extremely ſoluble in water. Its taſte is peculiar, and very pungent.

When the dry ſalt is heated ſuddenly and ſtrongly (as when a ſmall quantity is dropped on a red-hot earthen crucible) it inſtantly melts, takes fire and burns with great ebullition and hiſſing, and a red-blue flame, but without exploſion, with nearly the ſame appearance as when a lump of nitre is thrown on hot coals. Nitrat of ammonia is the only nitrat that deflagrates without the contact of any carbonaceous or inflammable matter, whence the immediate decompoſition of the ammonia may be inferred, the hydrogen of the alkali furniſhing inflammable matter for the oxygen of the nitric acid. This ſelf-inflaming property makes it neceſſary to uſe caution in heating any dry mixture of nitric acid and ammonia in cloſe veſſels. It has however been examined in this way by Mr. Davy, and the dry diſtillation of this ſalt is now particularly intereſting, as it furniſhes that curious gas the *nitrous oxyd*.

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[a] Reſearches.

The compact dry nitrat of ammonia, heated without addition in a ſmall glaſs retort, with the bulb of a thermometer incloſed, was found to undergo little or no change at a heat below 260°. From 275° to 300° it ſlowly ſublimes without decompoſition or without becoming fluid. At 320 it becomes fluid, ſlowly ſublimes, but alſo now begins to be decompoſed and to give out gaſſeous nitrous oxyd. From this the heat may be ſafely raiſed to about 440°, at which it is totally reſolved into the gas, and is diſſipated without leaving any reſidue. The priſmatic and fibrous varieties of this ſalt as they contain more water of cryſtallization, become fluid below 300°, and if not heated above 430°, they part with this water before they are decompoſed into *nitrous oxyd*. The further properties of this gas will be deſcribed under that article.

Nitrat of Barytes.

This ſalt is prepared artificially by diſſolving in dilute nitric acid the native or artificial *carbonat of barytes*, the methods of procuring which are deſcribed under that article.

On evaporating the ſolution and cooling, the nitrat of barytes ſeparates generally in regular octohedrons. This ſalt is of an opake-white, hard, and not deliqueſcent. It is one of the leaſt ſoluble of all the nitrats, requiring twelve times its weight of water at 60°, and about four parts of boiling water. Hence nitric acid poured into a concentrated ſolution of muriat of barytes, will cauſe an immediate white precipitate, which however is reſoluble in more water, and is nitrat of barytes.

This nitrat is compleatly decompoſed by heat, the acid is driven off, and the barytes remains pure and cauſtic, as already mentioned under the article *Barytes*.

Nitrat of Lime.

The production of this ſalt in calcareous buildings, &c. that have been uſed by animals, and its intimate connexion with the manufacture of nitre, has been fully deſcribed under the article *Nitrat of Potaſh*.

Nitrat of lime may be made artificially in great purity by ſaturating nitric acid with white marble or calcareous ſpar. This ſolution when evaporated to a very thick ſyrupy conſiſtence, cryſtallizes in a cool air into long priſms reſembling bundles of needles diverging from a common centre. If further evaporated, the ſolution when cold concretes into a fibrous and ſhapeleſs maſs.

This ſalt is bitter and pungent. It diſſolves in its own weight of boiling water, and twice its weight of cold water. It is very deliqueſcent. When heated *per ſe*, all the water and acid are driven off, and only pure lime remains, but if the heat be too ſtrong it vitrifies with the crucible employed, if of earth. Lime has been ſaid to be cryſtallizable in this way, but the experiment has not ſucceeded with many accurate chemiſts.

Nitrat of Strontian.

This ſalt is readily prepared by ſaturating dilute nitric acid with the native or artificial carbonat of ſtrontian (either of which it readily diſſolves) and evaporating the ſolution, which forms octohedral cryſtals much reſembling the nitrat of barytes in appearance, but much more ſoluble, requiring only five parts of cold water for their ſolution.

This ſalt is alſo compleatly decompoſable by heat, and the ſtrontian is left pure, ſo that it may readily be made to cryſtallize, as will be further mentioned under the article *Strontian*.

Nitrat of ſtrontian like many other ſalts with this baſis give a red flame to burning alcohol.

Nitrat of Magnesia.

This ſalt when cryſtallized aſſumes the form of rhomboidal priſms with obliquely truncated ſummits or of needles for the moſt part adhering to each other. Its ſp. gr. is = 1.73. Its taſte is pungent and bitter like that of nitrated lime. It is ſaid by Fourcroy to occur native and in nitre beds, and to be contained in the mother water of nitre, which is by no means improbable. When wanted however for chemical examination it is prepared by ſaturating nitrous acid with magneſia either pure or carbonated, and then evaporating the ſolution to an oily conſiſtence and ſubſequent cryſtallization.

Nitrat of magneſia when expoſed to the air attracts moiſture, and at length, though ſlowly, is reſolved into a fluid. If heated in a crucible it firſt melts in its water of cryſtallization, and after this has evaporated it becomes dry. On increaſing the temperature it gives out a little oxygen gas, which is preſently ſucceeded by nitrous vapour and nitrous acid, nothing remaining behind except the earth in a ſtate of purity.

This ſalt is ſoluble in its own weight of water at 50° Fahr. and in a conſiderably ſmaller proportion of boiling water; hence it depoſits cryſtals by cooling. It is alſo ſoluble in nine times its weight of alcohol.

When heated with combuſtible ſubſtances it gives out a few ſparks, but cannot, properly ſpeaking, be ſaid to detonate.

Nitrat of magneſia is decompoſable with abſtraction of its acid by the fixed alkalies; by barytes, ſtrontian, and lime, the magneſia in all theſe caſes being precipitated. Ammonia only in part decompoſes this ſalt, forming with the reſt a triple compound, the ammoniaco-magneſian nitrat. The ſulphuric, phoſphoric, and fluoric acids, with many of their neutral ſalts, decompoſe nitrat of magneſia, the earth combining with the added acid. If to a ſtrong ſolution of this ſalt, nitrat of lime alſo in denſe ſolution be added, a precipitation of the magneſian nitrat takes place, being deprived of its water of ſolution by the nitrat of lime.

Its component parts according to Kirwan are

46	Nitric acid
22	Magneſia
32	Water
100	

It is not made any uſe of.

Ammoniaco-magnesian Nitrat.

This ſalt appears in the form of ſlender acicular priſms: to the taſte it is bitter, acrid, and ammoniacal. It is prepared by a partial decompoſition of nitrat of ammonia by magneſia, or of nitrated magneſia by ammonia, or, ſtill better, by the direct union of the ſolutions of nitrat of ammonia and nitrat of magneſia.

By long expoſure to the air it attracts a certain quantity of moiſture, though it does not deliquiate. It requires eleven times its weight of water at the ordinary temperature for its ſolution, but a conſiderably ſmaller proportion of boiling water; hence this latter ſolution depoſits cryſtals as it cools.

It is not decompoſable by ammonia, but is ſo by the fixed alkalies and by all the alkaline earths, even magneſia; the ammonia being diſengaged. When dropped into a red hot crucible it undergoes a ſlight inflammation. By expoſure to a more gradual heat in a retort it gives out oxygen gas, nitrous vapour, nitric acid, azot and water, the ammonia being entirely decompoſed; pure magneſia remains behind.

It is compoſed according to Fourcroy of

78	Nitrat of magneſia
22	Nitrat of ammonia
100	

It is not made any uſe of.

Nitrat of Alumine.

This ſalt is uſually of a gelatinous conſiſtence, ſometimes though rarely it is obtained in the form of ſoft thin pliable cryſtalline plates. To the taſte it is ſour and aſtringent, it reddens blue vegetable colours and therefore contains an exceſs of acid. It has not been found native but may be prepared by digeſting pure alumine, or the precipitated earth of alum in nitric acid. In the latter caſe the earth is diſſolved with efferveſcence on account of a portion of carbonated alkali remaining in it, and this ſolution for the ſame reaſon is more readily cryſtallizable than when pure alumine is employed. By expoſure to the air it ſoon deliquiates. It is very ſoluble in water either hot or cold, and by evaporation and cooling generally takes the conſiſtence of jelly. It produces neither flame nor detonation by being heated with combuſtible bodies. When diſtilled *per ſe* the acid flies off at a moderate temperature, leaving the earth behind in a ſtate of purity. It is decompoſable by ſulphuric and muriatic acids and by all the alkaline baſes. It is not made any uſe of.

Nitrat of { Glycine. See Glycine.
Yttria. See Gadolinite.
Zircon. See Zircon.

Nitrite of Potash, or *Phlogiſticated Nitre*.

We have already mentioned that nitrous acid is compoſed of nitric acid and nitrous vapour. Now if nitrous acid and potaſh be mixed together the former is decompoſed; its nitric acid combines with the alkali forming nitre, while the nitrous vapour aſſumes a gaſſeous ſtate and flies off. Hence it appears that no ſuch ſalt as nitrite of potaſh can be made by the direct addition of its ingredients. We are indebted however to the ſagacity of Bergman and Scheele for the intereſting fact that if common nitre be melted *per ſe* and kept in this ſtate till part of its oxygen is driven off, the reſidual ſalt is a proper nitrite of potaſh. In this ſtate it deliquiates by expoſure to the air and is decompoſable by the addition of vinegar and any of the ſtronger acids, red nitrous vapour being given out. Dr. Thomſon is of opinion that nitrite of potaſh differs from the nitrat only in being ſaturated with nitrous gas: if this be the caſe the common nitrite ought to contain an exceſs of alkali.

It is made no uſe of.

Of the other nitrites nothing is known with any certainty.

NITROUS GAS, or Nitrous Air.

This ſubſtance has already been mentioned under the articles *Nitric acid* and *Eudiometry*, (to which we ſhall refer our readers) and many of its properties deſcribed. It has been there ſtated to be an *oxyd of azot*, or to conſiſt of azot united with a certain portion of oxygen but not ſufficient to conſtitute nitric acid. On the other hand there is another ſubſtance the *nitrous oxyd*, or *gaſſeous oxyd of azot* alſo compoſed of azot and oxygen, but in which the latter is in ſmaller proportion than in nitrous gas; ſo that nitrous gas is intermediate between the two, and being readily decompoſable by a variety of chemical agents (both thoſe that give and thoſe that take away oxygen) the production of nitrous oxyd or of azot on the one hand, and of nitric acid on the other, is always to be ſought for in all experiments on nitrous gas.

The nature of this gas was firſt explained by Dr. Prieſtley who ſhewed it to be a conſtituent of nitric acid, and ſhewed *how* it was converted into this acid, that is, by union with oxygen, and hence he ingeniouſly applied it to the analyſis of air containing oxygen, as has been already deſcribed under the article *Eudiometry*. Since his time this gas with all its varieties has been the ſubject of a great number of able reſearches, and its properties have been very fully explained.

Nitrous gas is obtained moſt conveniently during the ſolution of ſome of the metals in nitric acid. Moſt of the metals are acted on by this acid and decompoſe it, but in the proceſs ſome of them produce nitrous gas nearly pure; others, a mixture of nitrous gas and nitrous oxyd, and others nitrous oxyd nearly pure. The degree of concentration of the acid alſo and the temperature have a great effect on the gaſſeous product, for, when theſe are ſuch as to produce a very violent action, red nitrous vapour is alſo given out, and the products are different from thoſe that occur with a ſlower action.

Copper and mercury are the metals that produce the pureſt nitrous gas. Shreds of copper, or a ſmall quantity of mercury, ſhould be put into a bottle with a curved tube and the bottle nearly filled with an acid of ſuch ſtrength as to act moderately faſt at a heat tolerable to the hand, which will be made by diluting the concentrated acid with about three parts of water. As the metal diſſolves, the nitrous gas is given out, and after a ſmall quantity has run to waſte to diſplace the air of the veſſel, the gas may be collected in jars over water. During the proceſs a gentle heat may be uſed to haſten the production of gas. By this method nitrous gas may be procured ſo pure as not to contain more than $\frac{1}{60}$ to $\frac{1}{70}$ of impurity, which is azotic gas. According to Mr. Davy 100 cubic inches of this gas at 56° therm. and 30.9 bar. weigh 34.3 grains, which at 55° therm. and 30 bar. would weigh 34.26 grains.

Nitrous gas therefore is heavier than common air, according to Davy in the proportion of 1101.6 to 1000. 100 inches of common air weighing 31.1 in the ſame circumſtances in which nitrous gas weighs 34.26.

Nitrous gas is to a certain degree abſorbable by water. 100 cubic inches of the pureſt water deprived of the air it naturally contains by long boiling, and cooling over mercury, (that it may not again abſorb air from the atmoſphere) will abſorb about 11.8 of nitrous gas or ſomewhat more than $\frac{1}{9}$ of its bulk. Common ſpring water abſorbs a ſmaller quantity, but the abſorption however appears leſs than it really is, as the gas is partly decompoſed by the atmoſpherical air contained in all natural waters, and the azot of this air is given out, whilſt its oxygen forms nitric acid with the abſorbed nitrous gas. Water ſaturated with nitrous gas has no diſtinguiſhing taſte, and if the water be previouſly boiled and cooled over mercury, it ſhews no acidity by the moſt delicate teſts. Mr. Davy finds (contrary to the opinion of Humboldt,) that nitrous gas is not in the leaſt altered or decompoſed by ſolution in pure water, and that it is again totally expelled by a boiling heat unaltered.

Nitrous gas is immediately fatal to animals encloſed in it. Mr. Davy had the raſhneſs to inſpire a ſmall quantity of it which gave a very burning aſtringent taſte to the mouth and throat (owing no doubt to the formation of nitrous vapour by union with the common air in theſe organs) and the conſequence was ſevere inflammation which laſted ſome hours.

This gas diſſolves readily in many of the acids. With the ſulphuric it gives a purple brown colour, and when in the form of nitrous vapour it cauſes this acid to cryſtallize. The change produced in the conſtitution of *nitric acid* by the abſorption of this gas has been fully detailed under this article.

The habitudes of nitrous gas with combuſtible bodies are peculiar. A taper dipped in this gas is immediately extinguiſhed, but pyrophorus burns with increaſed flame, as Dr. Prieſtley diſcovered. Charcoal is ſlowly conſumed in it if kept at a red heat. The particulars of ſome of theſe experiments require a further notice, as they lead to determine the compoſition of the gas.

[a] Dr. Prieſtley incloſed a piece of charcoal (recently heated ſtrongly in ſand) in nitrous gas and threw on it the rays from a lens for a conſiderable time. The bulk of air was not much diminiſhed, and when examined it was found to contain little or no fixed air, and extinguiſhed a candle.

The ſame experiment was repeated by Mr. Davy. The volume of the gas after the heating of the charcoal for half an hour was increaſed by about $\frac{1}{24}$. On adding a ſolution of pale green ſulphat of iron (which totally abſorbs nitrous gas) a diminution of only $\frac{1}{32}$ of the whole took place, but on throwing up cauſtic alkali a rapid abſorption enſued and the gas was reduced to half its original bulk. Part of the reſidue was mixed with its own bulk of oxygen and the electric ſpark paſſed through, but no effect took place, and hence it was proved to be pure azot. The quantity of the latter therefore was eſtimated to be the whole of the azot contained in the nitrous gas employed, and the proportion of oxygen was inferred from the carbonic acid produced, and which was abſorbed by the alkali, and hence Mr. Davy infers that 100 grains of nitrous gas are compoſed of 56.5 oxygen and 43.5 azot.

But it was poſſible that ſome nitric acid might have been generated by the combuſtion of charcoal in the gas which would eſcape detection in the above mode of analyſing, to determine which the experiment was repeated as before, and ſome pale green ſulphat of iron thrown up to the reſidual gas, after which a few drops of pruſſiat of potaſh were added. Now if any nitric acid had been generated it would have been abſorbed by the ſulphat of iron and reduced a part of it to that ſtate of oxydation in which it gives a *blue* precipitate with the pruſſiat; but the precipitate was ſtill white, and hence it is inferred that no nitric acid was produced.

Pyrophorus was found to burn with eaſe in nitrous gas, and the reſidue was pure azot. From an experiment made with this ſubſtance and an eſtimation of the reſiduary azot, the compoſition of 100 grains of nitrous gas would be 53.4 of oxygen and 46.6 azot. But the decompoſition by charcoal appears the moſt correct, ſo that on the whole it may be eſtimated that 100 grains of this ſubſtance contain 56 of oxygen and 44 of azot.

Some combuſtible ſubſtances burn in nitrous gas if actually in vivid combuſtion when they are introduced, but cannot be brought to this ſtate when heated in the gas. Phoſphorus is an example of this, as it may be fuſed and even ſublimed in nitrous gas without change, but when already inflamed it continues to burn in the gas with nearly as much vividneſs as in oxygen.

Burning ſulphur however is inſtantly extinguiſhed in nitrous gas.

The electric ſpark when taken repeatedly in nitrous gas over water, diminiſhes it to one fourth of its original quantity,[b] at the ſame time that nitric acid is produced, litmus encloſed in it being ſtrongly reddened. If the electrization be carried on in contact with mercury the diminution is only one half; and a white powder is obtained which is the nitrat of this metal. The air remaining after the utmoſt effect of the electric ſpark appears to be pure azot. This decompoſition is much more rapid than the formation of nitric acid by the electrization of common air or any mixture of ſimple oxygen and azot.

In this proceſs Berthollet conjectures that nothing is added or taken away by the ſurrounding bodies, but that the whole change takes place in the nitrous gas itſelf by the condenſation of its oxygen into one portion of the azot to form the nitric acid, and its conſequent deſertion of the other portion. Neither inflammation nor detonation is produced by paſſing a ſtrong ſhock through a mixture of hydrogen and nitrous gas.

Mere heat does not produce any ſenſible change on this gas.

Much has already been mentioned under the article *Eudiometry* concerning the abſorption of nitrous gas by a ſolution of ſulphat of iron, (firſt noticed by Dr. Prieſtley) and the very elaborate inveſtigation of this difficult ſubject by Humboldt and Vauquelin, together with ſome of the objections brought by Berthollet on the ſource of the ammonia formed in this proceſs. Others of equal force have been urged by Mr. Davy, to whoſe experiments on this ſubject we muſt refer the reader. From them he concludes that the *red* or fully oxygenated ſulphat of iron has little or no affinity with nitrous gas, and that the common green vitriol abſorbs nitrous gas only in proportion to the quantity of ſuboxygenated or *green* ſulphat which it contains, (for an account of the difference between theſe two ſalts ſee the article *Iron*) and that at a common temperature the nitrous gas is ſimply diſſolved therein without being decompoſed.

A highly concentrated ſolution of green ſulphat will diſſolve about 12 times its bulk of nitrous gas.

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[a] Experiments on Air, Vol. II. p. 89.

[b] Prieſtley.

The ſame difference as exiſts between the red and green ſulphat of iron is found in the red and pale muriat of iron and ſimilar habitudes with nitrous gas; for the red muriat has very little action on this gas, but the pale muriat abſorbs it with ſtill more eagerneſs than the pale ſulphat. This muriat is formed by diſſolving iron filings in muriatic acid, taking care to keep a quantity of undiſſolved metal in the ſolution, and preſerving it in a cloſely corked bottle. This ſolution is of a pale green colour, and gives a white precipitate with pruſſiat of potaſh. One cubic inch of the ſolution highly concentrated will abſorb nearly 24 inches of pure nitrous gas, which changes the colour to a very dark brown but produces no precipitate. The ſolution of the green muriat or ſulphat before it is employed to abſorb nitrous gas for eudiometrical purpoſes, ſhould be boiled for a few minutes to expel the ſulphuretted hydrogen which it may contain.

The other facts known relating to its decompoſition will be mentioned in the following article of *nitrous oxyd*, which as it contains leſs oxygen than nitrous gas, is produced by the action of deoxygenating ſubſtances on nitrous gas.

NITROUS GAS ETHERIZED is a peculiar inflammable gas formed by the mutual action of nitric acid and alcohol. See *Ether nitrous*.

NITROUS OXYD, or *Gaſſeous oxyd of azot*. *Dephlogiſticated nitrous air* of Dr. Prieſtley.

This gas was firſt diſcovered by Dr. Prieſtley by expoſing iron to nitrous gas; he has alſo given a number of curious experiments on the mode of its formation and has detailed a great number of its phyſical and chemical properties. From the circumſtance of its ſupporting combuſtion in an eminent degree (in many inſtances almoſt equal to oxygen gas in this reſpect) and being produced by the decompoſition of nitrous gas, Dr. Prieſtley gave it the name of *dephlogiſticated nitrous air*, but as this term is founded on the doubtful theory of phlogiſton, and as it might lead to the miſtake of ſuppoſing that this gas really contained more oxygen than nitrous gas, Mr. Davy's appellation of *nitrous oxyd* is much to be preferred.

Since the experiments of Dr. Prieſtley this ſubſtance has been the ſubject of very careful reſearch by the Dutch chemiſts, and other philoſophers, and in particular by Mr. Davy whoſe excellent memoir on nitrous oxyd has almoſt ſupplied every thing that the great diſcoverer had left to his ſucceſſors.

Nitrous oxyd is a ſubſtance compoſed, like nitrous gas, of azot and oxygen, but in which the oxygen is in a ſmaller proportion, ſo that in this reſpect it holds an intermediate place between nitrous gas and atmoſpheric air, which laſt is the leaſt oxygenated of all the ſimple natural combinations of theſe two elements. However, though nitrous oxyd contains leſs oxygen than nitrous gas, the mode of combination appears to differ conſiderably and much to influence its power of containing combuſtion and other chemical properties.

The diſtinguiſhing properties of nitrous oxyd are the following: it is readily abſorbed by water to about half the bulk of this fluid, and the ſolution has a ſweetiſh taſte, but it is not in the leaſt degree acid: a candle burns in it with an enlarged flame and crackling noiſe: phoſphorus actually ignited burns in it with nearly as much brilliance as in oxygen gas: ſulphur when burning in the common way with a feeble blue flame is immediately extinguiſhed in the gas, but when burning vehemently before introduction, the combuſtion continues with increaſed rapidity: ignited charcoal burns in it nearly as in oxygen gas: neither oxygen nor nitrous gas have any ſenſible effect on it at a common temperature: animals incloſed in the gas ſoon die, but it may be breathed when mixed with common air. Other properties of this gas will preſently be mentioned, but the action of water, of combuſtible bodies, and the inaction of oxygen and nitrous gas, will ſufficiently diſtinguiſh it.

Therefore in the decompoſitions of nitrous gas the quantity of nitrous oxyd produced may be found by agitating the reſidual gas in water. But if any unaltered nitrous gas remain (which is very commonly the caſe, and is ſhewn by the diminution and red fumes with oxygen gas) it muſt be previouſly abſorbed by ſulphat or muriat of iron, which has no effect on nitrous oxyd, after which the nitrous oxyd may be abſorbed by water, and the remaining gas is pure azot.

Nitrous oxyd has never been found native nor has it been detected in any of the proceſſes of nature. It is produced artificially in ſeveral ways, namely:

1ſt. From the decompoſition of nitrous gas by thoſe ſubſtances which abſorb its oxygen.

2dly. From the action of nitric acid on many of the metals under particular circumſtances.

3dly. From the decompoſition of nitrat of ammonia by ſimple diſtillation.

Each of theſe methods ſhall be diſtinctly noticed.

The ſubſtances that abſorb oxygen from nitrous gas are many of them thoſe that abſorb oxygen from common air, ſo that the ſame experiments which ſucceed in common eudiometric proceſſes will often convert nitrous gas into nitrous oxyd.

The ſulphite of potaſh effects this change with greater rapidity than any other ſubſtance. Mr. Davy found that at temperature 46°, 16 cubic inches of nitrous gas were converted in leſs than an hour into 7.8 inches of nitrous oxyd by about 100 grains of pulverized ſulphite of potaſh, retaining its water of cryſtallization. This appears to act by the ſimpleſt poſſible affinity, namely that of the ſulphite for that part of the oxygen which makes the difference between nitrous gas and nitrous oxyd. The azot with which nitrous gas is always mixed remains unaltered.

Nitrous gas expoſed to dry muriat of tin is ſlowly converted into nitrous oxyd, apparently by the ſame ſimple affinity as by the ſulphites.

All the dry ſulphurets produce the ſame change on nitrous gas in about the ſame time that they would require to deoxygenate common air.

Iron filings and ſulphur mingled together and moiſtened produce the ſame effect on nitrous air, and the change is effected in about twelve hours.

Iron filings alone produce the ſame change, which was Dr. Prieſtley s firſt experiment by which he diſcovered this gas.

The preſence of moiſture has been ſuppoſed neceſſary to the ſucceſs of the experiment, but this does not ſeem to have been the caſe. Dr. Prieſtley filled a half pint phial with nails and then with quickſilver, after which the latter was diſplaced by nitrous gas, and the phial was left with its mouth ſtanding over mercury.

No moiſture was intentionally introduced here, but in the courſe of two months the gas was converted into nitrous oxyd. Dr. Prieſtley however adds that when the proceſs is carried on over water the change is effected in a few days.

When dry nitrous gas and dry ſulphuretted hydrogen are mixed together over mercury a mutual decompoſition ſlowly takes place.[c] The gaſſes are diminiſhed, ſulphur is depoſited, nitrous oxyd is formed, and ſigns of the production of ammonia and water are perceived.

As the ſulphur is depoſited in this experiment, and no ſulphuric acid produced, the hydrogen muſt be the ſole deoxygenating agent, but as ſome ammonia is produced, a portion of the azot of the nitrous gas muſt alſo be ſeparated to contribute to the formation of the alkali. A part of the hydrogen therefore appears to unite with the exceſs of oxygen of the nitrous gas and forms water, and another part of it with a portion of the azot of the nitrous gas forms the ammonia. But the removal of this azot from the nitrous gas would have a direct effect in preventing its converſion into nitrous oxyd, and therefore the abſtraction of its oxygen muſt be greater in this than in the ſimple decompoſitions of nitrous gas, and the entire quantity of nitrous oxyd produced ſhould be leſs. There is too much variation however in the different experiments to allow of much accuracy of reſults with theſe complicated agents.

Zinc filings convert nitrous gas into nitrous oxyd with as much eaſe as iron filings, but only when in contact with water. Ammonia is produced and the zinc is changed to a white oxyd, which can only be explained by the ſuppoſition of a double decompoſition of the water and the nitrous gas, the latter yielding part of its azot to part of the hydrogen of the water for the ammonia; part of its oxygen to the remainder of the hydrogen in order to produce the change from nitrous gas to nitrous oxyd; and the oxygen ariſing from the decompoſed water uniting with the zinc.

Another method of producing nitrous oxyd has been ſtated to be during the ſolution of ſeveral of the metals in nitric acid under particular circumſtances of concentration, heat, &c. The gas in this caſe is always mixed with nitrous gas, and often with azot. The metals from which it is produced with the greateſt eaſe are iron, zinc, and tin. Iron produces a variable mixture of nitrous gas and nitrous oxyd. If a cold ſaturated ſolution of nitrat of iron is heated, much nitrous oxyd is produced.[d] A great quantity of it is alſo given out by adding iron filings to nitrat of iron, and the filings paſs to the ſtate of black oxyd, as Berthollet has obſerved. When tin is diſſolved in concentrated acid of about 1.4 ſp. gr. (which is nearly as ſtrong as is able to act on this metal) the gas is a mixture of about one part of nitrous oxyd with two of nitrous gas, and a very ſmall quantity of azot. With an acid of 1.24 the proportion of nitrous oxyd is greater, and increaſes to about $\frac{3}{4}$ of the whole towards the end of the proceſs.[e]

Zinc alſo yields this gas during the action of nitrous acid of any ſpecific gravity, and in moſt abundance when the acid is dilute, and towards the middle and end of the proceſs. The nitrat of zinc whilſt diſtilling to dryneſs gives much of the nitrous oxyd. From 100 grains of zinc during their ſolution in 300 grains of nitric acid of 1.43 diluted with 14 times its weight of water, Mr. Davy obtained 26 cubic inches of gas, of which $\frac{7}{36}$ were nitrous gas, $\frac{17}{36}$ nitrous oxyd, and the remainder azot.

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[c] Davy.

[d] Prieſtley.

[e] Prieſtley and Davy.

It is to be obſerved that ammonia is known to be produced in very ſenſible quantities during the ſolution of theſe three metals in nitric acid, and the production of this alkali ſeems to be intimately connected with the evolution of nitrous oxyd, as has been already explained.

The third method of producing nitrous oxyd has been ſtated to be by the diſtillation of *nitrat of ammonia*. This has been already mentioned generally under that article, but as this is the moſt economical, and altogether the beſt method of preparing the gas for chemical purpoſes and that which is actually uſed in the laboratory, the following directions of a very able and practical chemiſt may be uſeful.[f] "Introduce into a glaſs retort ſome pure nitrat of ammonia, and apply the heat of an Argand's lamp; the ſalt will ſoon liquefy, and when it begins to boil gas will be evolved. Increaſe the heat gradually till the body and neck of the retort become filled with a tranſparent milky white vapour. In this ſtate the temperature of the fuſed nitrat is between 340° and 480°. After the decompoſition has proceeded for a few minutes, ſo that the gas evolved quickly enlarges the flame of a taper held near the orifice of the retort, it may be collected over water, care being taken during the whole proceſs never to ſuffer the temperature of the fuſed nitrat to riſe above 500°, which may eaſily be judged of from the denſity of the vapours in the retort, and from the quiet ebullition of the fuſed nitrat, for if the heat be increaſed beyond this point the vapours acquire a reddiſh and more tranſparent appearance, and the fuſed nitrat begins to riſe and occupy twice the bulk it did before. The nitrous oxyd after its generation is allowed to ſtand over water for at leaſt ſix hours, and is then fit for reſpiration and other experiments."

It may be added that as there is always ſome loſs of the gas from abſorption by the water over which it ſtands, the ſame water may be uſed repeatedly.

Having thus given the general methods of procuring this gas, we proceed to deſcribe its chemical properties more particularly.

Dr. Prieſtley found that water readily abſorbed about half its bulk of this gas, which is again expelled unaltered. Mr. Davy found nearly the ſame; the utmoſt abſorption by water thoroughly purged of air by boiling, and cooling under mercury being 54 cubic inches of gas to 100 of water. Conſequently 25300 grs. (the weight of 100 cubic inches of water) will abſorb 27 grains of the gas. The aqueous ſolution is ſenſibly ſweet to the taſte, but ſhews no marks of acidity. The gas is again expelled from the water by heat unaltered. When the ſaturated water is ſhaken with carbonic acid and ſulphuretted hydrogen theſe are abſorbed, and the nitrous oxyd expelled unchanged: but on the other hand, the oxyd expels moſt of the other gaſſes from water and takes their place in the ſolution.

Ether and alcohol and the eſſential oils abſorb this gas in larger quantity than water, but apparently produce no change in its chemical conſtitution.

The concentrated ſulphuric and nitric acids neither abſorb nor alter it: the weaker acids ſimply abſorb it.

Neither the green muriat nor green ſulphat of iron, nor muriat of tin, nor any of the common deoxygenating liquid ſubſtances appear to have any effect on this gas at common temperatures. The ſame may be obſerved of gaſſeous bodies, ſuch as nitrous gas and ſulphuretted hydrogen. Neither is there any alteration produced on nitrous oxyd by the ſubſtances which impart oxygen. Even oxymuriatic gas the moſt powerful oxygenating agent mingles with nitrous oxyd unaltered.

None of the alkalies either pure or carbonated, ſolid or in ſolution, have any effect on this gas when preſented to them *ready formed*, but if the alkalies are brought in contact with nitrous oxyd in its *naſcent ſtate*, a ſingular combination is formed.[g] The method of making this ſpecies of neutral ſalt with potaſh, is to mix ſulphite of potaſh with a little cauſtic potaſh (retaining the water of cryſtallization) and incloſe it in an atmoſphere of nitrous gas. The ſulphite firſt acts on the nitrous gas, converting it to nitrous oxyd, as already deſcribed, (itſelf changing thereby to ſulphat of potaſh) and the nitrous oxyd in the moment of formation is abſorbed by the free alkali, and forms this ſingular combination. When the proceſs is finiſhed the ſaline maſs conſiſts of ſulphat of potaſh, probably with ſome undecompoſed ſulphite, of the combination of nitrous oxyd with potaſh, and generally of ſome unſaturated potaſh and carbonat of potaſh. By ſolution in water and cryſtallization, the ſulphat and ſulphite of potaſh may be ſeparated, theſe being much leſs ſoluble in water than the other ſalt, but there is no means of ſeparating entirely the carbonat of potaſh.

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[f] Accum's Syſtem of Chemiſtry.

[g] Davy.

The ſalt of nitrous oxyd and potaſh is readily ſoluble in water, has a cauſtic pungent taſte, and does not part with the nitrous oxyd by boiling. But if any acid is added, a briſk effervеſcence takes place, and the oxyd is given off pure unleſs the ſalt contained alſo an alkaline carbonat, in which caſe the gas is mixed with carbonic acid. Carbonic acid gas thrown into a ſolution of the ſalt expells the nitrous oxyd, ſo that the affinity of the latter for alkalies is weaker than that of the weakeſt acid. From a rough eſtimate Mr. Davy conjectures that this ſalt conſiſts of about 3 parts of alkali and 1 of nitrous oxyd by weight.

A ſimilar ſalt may be formed with ſoda by the ſame methods, employing the ſulphite of ſoda and cauſtic ſoda, but the ready ſolubility of ſulphat of ſoda would render it more difficult to procure the nitrous oxyd ſalt ſeparate.

The phenomena that attend the combuſtion of different bodies in this gas are highly intereſting as they afford the only means of decompoſing this ſubſtance, and of determining the nature and proportion of its conſtituent parts.

Dr. Prieſtley firſt obſerved that when a lighted taper was let down into a jar of this gas it burned with an increaſed flame, and a crackling noiſe ſimilar to the combuſtion in oxygen gas, but there is this eſſential difference between the two gaſſes (as far as relates to their power of ſupporting combuſtion) which is, that when a ſubſtance previouſly ignited in any degree in the open air is introduced into oxygen gas, the combuſtion inſtantly increaſes and is raiſed to intenſe vehemence; whereas, in nitrous oxyd bodies previouſly ignited only to a low degree are immediately extinguiſhed, and it is only when already in *ſtrong* ignition or by the application of a ſtrong heat to them after incloſure in this gas, that the combuſtion goes on at all, and then riſes to a greater intenſity than in common air. Thus if phoſphorus is incloſed in nitrous oxyd and touched with an iron heated to a low redneſs, the phoſphorus melts, and may even be ſublimed unaltered, but if touched with an iron heated white hot, a violent detonation takes place. Much caution is required in performing this experiment. If the phoſphorus be previouſly warmed or ſublimed in the gas, a violent detonation cannot be avoided when the heat is afterwards raiſed to ignition, on account of the veſſel being already full of phoſphoric vapour, but to make this ſubſtance burn quietly and vividly in nitrous oxyd as it does in oxygen, it ſhould be previouſly ſet fire to and ſuddenly introduced into the nitrous oxyd.

Phoſphorized hydrogen gas and nitrous oxyd mixed together may be fired with the electric ſpark.

Sulphur when introduced cold into the gas cannot be fired by applying an iron wire even white hot, and it may be fuſed and ſublimed in the gas without alteration. Even when it is previouſly kindled, if only burning weakly with a faint blue flame, it is immediately extinguiſhed in the gas. But if it is in ſtrong ignition and then introduced in the gas it burns vividly, with a roſe-coloured flame. In this experiment and that with phoſphorus, Mr. Davy ſucceeded by introducing into the jar containing the nitrous oxyd, the phoſphorus or ſulphur in a ſmall tube containing oxygen, balanced ſo as to ſwim on the ſurface of the mercury without communicating with nitrous oxyd. The phoſphorus or ſulphur was fired in the oxygen by an ignited iron wire, by which at the moment of combuſtion the tube containing it was raiſed into the nitrous oxyd, and thus the inflammation continued. The combuſtion with ſulphur however will ſucceed in the following manner:[h] Dip a ſlip of copper into melted ſulphur; when cold ſet fire to it, and when in ſtrong combuſtion introduce it into a jar containing the gas, when it will continue to burn with a beautiful roſe-coloured flame.

Iron wire, charcoal, pyrophorus, and many other combuſtible ſubſtances, may be burned in the nitrous oxyd by ſimilar means.

In all theſe combuſtions the oxygen neceſſary to this proceſs muſt be furniſhed by the nitrous oxyd, conſequently this gas muſt either be totally decompoſed, or converted into a compound in which the oxygen is in a leſs proportion than before; in the former caſe the reſidue after combuſtion will be mere azotic gas, (that is, in caſe no new gas is generated by the act of combuſtion) and in the latter it will be a compound conſiderably reſembling atmoſpheric air in conſtitution. Hence too it appears probable that the ſtate of oxygenation of azot which conſtitutes atmoſpheric air, is a preciſe point or mode of combination of azot at which the deoxygenation of nitrous oxyd would have a tendency to ſtop, as nitrous oxyd itſelf is with regard to nitrous gas; and nitrous gas with regard to nitric acid.

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[h] Accum.

Two more decompoſitions of nitrous oxyd require to be noticed, that by the electric ſpark ſimply, and that by hydrogen aſſiſted by the electric ſpark.

Dr. Prieſtley found that on taking the electric ſpark frequently in nitrous oxyd, no perceptible change was produced in its quantity, but it was become immiſcible with water.

The ſame experiment was repeated by Mr. Davy with accuracy, and by paſſing 150 ſtrong ſtrokes through 7 ten-grain meaſures of pure nitrous oxyd, after which it was reduced to 6 meaſures. This reſidue mixed with 6 meaſures of nitrous gas and a little water, gave red fumes, and a diminution of bulk took place nearly equal to that which common air would produce with nitrous gas. In another experiment the ſame quantity of nitrous oxyd was reduced to 6½ meaſures, and red cabbage juice ſaturated with nitrous oxyd, and rendered green by alkali, had its red colour reſtored in the proceſs, thus ſhewing the production of an acid, which could be no other than the nitric. The effect of electrization therefore is entirely to decompoſe the nitrous oxyd, to condenſe a larger proportion of the oxygen into one portion of the azot and convert it into nitrous acid, and conſequently to leave a ſmaller proportion of oxygen in the remainder, and thus produce the gas reſembling atmoſpheric air.

A ſimilar change is produced by tranſmitting nitrous oxyd through a red hot glazed porcelain tube.

When hydrogen and nitrous oxyd are mixed and the electric ſpark paſſed through, they explode with conſiderable violence, and with a bright red light. The bulk of the reſidue is always much leſs than the united bulk of the gaſſes before the exploſion, but the exact quantity (the gaſſes being pure) depends on the proportion in which the two are mixed. The nature of the reſidue alſo varies according to the proportion of the gaſſes: where the hydrogen is to the nitrous gas as 50 to 40, the decompoſition is perfect, the reſidue is entirely azot, about a fourth more in bulk than the nitrous oxyd, and conſequently is not changed by nitrous gas nor abſorbed by water. As all the hydrogen diſappears, it muſt unite with the oxygen of the nitrous oxyd to form water, and no traces of nitric acid can be perceived. Where the hydrogen is leſs in quantity than the nitrous oxyd, the effect ſeems to be that of the former inſtance combined with that produced by the ſimple electrization of the nitrous oxyd, ſo that the products are, water, azot, nitric acid, and a mixture of azot and oxygen.

The decompoſition of nitrous oxyd by charcoal, hydrogen, and phoſphuretted hydrogen, were all found by Mr. Davy's experiments to offer a very ſatisfactory agreement in the reſults, conſidering the difficulty of analyſis. The ſmalleſt quantity of oxygen found in the gas was 35 in 100, by weight, and the largeſt 39. If the mean between the two is taken, it may be concluded that 100 grains of it are compoſed of about 63 of azot and 37 oxygen; and that 100 cubic inches weigh 50 grs. at 55° temperature, and 30 inches of atmoſpheric preſſure.

We may conclude this article with the table of the combinations of azot given by Mr. Davy, which may be conſidered on the whole as the neareſt approximations to accuracy which we poſſeſs.

100 cubic inches at 55° Therm. and 30 Bar.

		grains
Of azot - - - - - -	weigh	30.04
Oxygen - - - - - - -		35.06
Atmoſpheric air - - -		31.10
Nitrous oxyd - - - -		50.20
Nitrous gas - - - - - -		34.26
Gaſſeous nitric acid - -		76.00

Compoſition of 100 grains of the above ſubſtances.

	Azot	Oxygen
Atmoſpheric air - -	73.00	27.00
Nitrous oxyd - - -	63.30	36.70
Nitrous gas - - -	44.05	55.95
Nitric acid - - - -	29.50	70.50

O

OBSIDIAN. Iceland Agate.

Its uſual colour is pure black, whence it paſſes into greeniſh and greyiſh-black, blackiſh, bluiſh, and greeniſh-grey, and ſmoke-grey. It occurs in maſs, and in rough, roundiſh, detached pieces. Internally its luſtre is more or leſs ſhining and vitreous. Its fracture is perfect and large conchoidal. Its fragments are indeterminately angular and very ſharp-edged. It is more or leſs tranſparent on the edges. It is hard, but eaſily frangible. Sp. gr. 2.34. Before the blow-pipe it melts without addition into a greyiſh-white opake ſomewhat porous enamel. The Obſidian of Iceland has been decompoſed by Bergman, and more recently by Abildgaard, with the following reſults:

Berg.		Abild.	
69	—	74	Silex
22	—	2	Alumine
9	—	14	Oxyd of iron
100		90	

The hardneſs and opake blackneſs of this mineral added to the high poliſh of which it is capable, have cauſed it to be employed for various kinds of ornaments. In Peru at the time of its conqueſt by the Spaniards, it was uſed for mirrors, and has been faſhioned in Europe into reflectors for teleſcopes.

It occurs in large beds in the Lipari iſlands, near Sicily, where it evidently paſſes into pumice: it is met with near Tokay in Hungary, in ſmoke-coloured nodules in decompoſing granite and porphyry (theſe nodules ſometimes go by the name of *Lux ſapphire*). It abounds in Iceland, not only in the vicinity of Hecla but elſewere; alſo in the iſland Melos in the Archipelago; near Grantola in the north of Italy: in the iſland of Madagaſcar, in Peru and Siberia.

It is one of the minerals whoſe origin is warmly conteſted by the Neptunians and Volcaniſts, many of the latter denominating it vitreous lava.

OIL. Huile. *Fr.* Oehle. *Germ.*

Various ſubſtances are included under the general appellation oil, which however differ ſo eſſentially in many particulars from each other, as to render it impoſſible to comprehend them under any proper ſpecific definition: we have therefore divided this claſs of bodies among the four following articles.

Oils Vegetable Unctuous.

Unctuous or fixed vegetable oil occurs principally in the cotyledons of certain ſeeds, and ſometimes though rarely in the pulp or fleſh of fruits. In the former it is always mixed with a greater or ſmaller proportion of fecula and mucilage, on which account theſe ſeeds when rubbed in a mortar with cold water, form with it a white opake milk-like fluid called an *emulſion;* from which by long ſtanding (or more ſpeedily by the addition of an acid) the oil ſeparates, riſing to the ſurface in the form of a thick cream.

There are two ways of extracting oil: the firſt and moſt uſual is by means of preſſure; the ſecond is by immerſion in hot water; in this latter caſe the oil ſeparates from the other ingredients with which it is naturally mixed, and riſes by the force of gravity to the ſurface of the water, from which it is ſkimmed off.

Recently drawn oil however is more or leſs impure on account of its containing a variable proportion of mucilage, fecula, and perhaps other ſubſtances: of theſe a part is always depoſited by reſt, eſpecially if the contact of the air is not entirely excluded; but another portion remains in permanent ſolution, and to this that partial ſpontaneous decompoſition in oils called *rancidity* is principally owing.

Fixed oil at the common atmoſpherical temperature is uſually in the ſtate of a moderately thick, but not, properly ſpeaking, viſcid fluid; to the touch it is remarkably ſmooth and unctuous; it has a mild ſub-nauſeous taſte, and a peculiar flavour, according to the vegetable from which it is procured. Its colour when recent has more or leſs of a greeniſh tinge, which by keeping becomes yellow, and in ſome inſtances orange-coloured, verging on red. Its ſpecific gravity is uſually between that of alcohol and of water, hence it ſinks in the former and floats on the ſurface of the latter of theſe fluids. There is nothing in which oils differ from each other ſo much, as in the temperature at which they congeal; ſome continue ſolid at the higheſt atmoſpherical temperature, as palm oil, and the reſt of the vegetable *butters* (as they are called from this very circumſtance) others require being cooled down to the freezing point of water, and others again are capable of enduring a much greater cold without ſolidifying.

Water ſeems to be incapable of combining with fixed oil in any proportion: if the two fluids are ſtrongly ſhaken together in a half-filled vial, the oil is broken into very minute globules, and thus gives the water the appearance of thin milk or whey, but after ſtanding for a few ſeconds the whole of the oil riſes to the ſurface, and the two liquors remain as clear and diſtinct as at firſt. That a conſiderable attraction ſubſiſts between water and oil is however manifeſt from the well-known fact, that if a drop of oil be let fall into a baſon of water, it does not retain its globular form, but immediately ſpreads itſelf into a thin irideſcent film with which the whole ſurface of the water is covered.

The fixed oils are ſo called becauſe they are incapable of being volatilized by heat without decompoſition: when therefore any of them, olive oil for example, is heated in a cloſe diſtillatory apparatus, as ſoon as the fluid has arrived at its boiling point a white vapour is diſengaged, conſiſting of oil, carburetted hydrogen, and carbonic acid; of theſe the firſt is for the moſt part condenſed in the receiver, while the other two, holding a portion of oil in ſolution, eſcape in the form of permanent gas; when every thing volatile has been driven off, nothing remains in the retort but a little charcoal. The oil which is found in the receiver is lighter, more limpid and volatile than that from which it was procured, and theſe qualities are obſerved to increaſe by each ſucceſſive diſtillation, carbon and carburetted hydrogen being diſengaged as at firſt. By treating in this manner the product of each diſtillation the oil at length entirely diſappears, being partly decompoſed and partly carried off in ſolution by the carburutted hydrogen gas.

If oil inſtead of being diſtilled is heated in an open kettle, its colour by degrees becomes deeper, a highly inflammable and fetid vapour eſcapes, and the remaining oil is found to be thick, viſcid, and when ſpread over wood or any other ſubſtance and expoſed to the air, congeals into a ſolid, tough, tranſparent varniſh. In this ſtate it is called boiled or *drying* oil. It has not been very ſatisfactorily ſhewn what takes place on this occaſion, but it is probable that the mucilage and fecula are for the moſt part charred and decompoſed, that the water with which they were combined is volatilized, that a ſmall portion of the oil itſelf is driven off, and that the reſidue has abſorbed ſome oxygen from the air. When oil is expoſed to a high heat and at the ſame time to the free contact of the atmoſphere it takes fire, and burns with a copious flame, accompanied by a thick black ſmoke; the combuſtion of oil however does not readily take place except by means of a wick: if an Argand lamp is uſed for this purpoſe the flame is of a pure white colour, and no ſmoke is produced, the whole of the oil undergoing entire combuſtion. In this proceſs the oil, according to Lavoiſier, is converted into water and carbonic acid, in ſuch proportions, that its conſtituent parts may be ſtated at 21 of hydrogen, and 79 of carbon. In this however no allowance is made for the oxygen which oil no doubt contains, ſo that at beſt the given proportions can be looked upon only as a looſe approximation to the truth.

It is known that ſome of the fixed oils (and probably all of them) abſorb oxygen, either from the air or from oxygen gas, at the common temperature. Berthollet diſcovered that oil of almonds in a jar half filled with oxygen gas ſtanding over water, had in the courſe of a month abſorbed nearly the whole of the oxygen, and at the ſame time depoſited a number of white concretions forming a thin ſtratum between the water and the oil. In another experiment this able chemiſt expoſed a very thin ſtratum of oil on the ſurface of water to the contact of atmoſpheric air for three months: at the end of this period the oil was found converted into a white concrete ſubſtance, friable at a low temperature, but fuſible at a leſs heat than that required for the melting of wax.[a] By long expoſure to the air ſome oils, as olive oil, become rancid, in which ſtate they exhibit the following characters: the colour is deepened, the odour becomes ſtrong and diſagreeable, the conſiſtence is viſcous or ropy, and vegetable blues are changed to red, ſhewing the developement of an acid. Other oils on the contrary in ſimilar circumſtances only dry to a tough varniſh. The former are often called *fat oils*, and the other ſpontaneouſly *drying oils*.

Of the ſimple combuſtibles, hydrogen in the ſtate of gas is ſlowly and ſparingly taken up by oil, but the effect of this combination has not been examined. Charcoal appears to be wholly inſoluble in oil, but when newly burnt it has the property of bleaching and purifying it to a conſiderable degree.

Phoſphorus by the aſſiſtance of heat is ſoluble in oils though ſparingly, and the compound has the property of becoming luminous if ſmeared thin over any dry ſubſtance and expoſed to a warm air. A few drops of the phoſphorized oil if rubbed on the hands or face, cauſe them to ſhine in the dark without any riſk of injury from the ſlow combuſtion of this highly inflammable ſubſtance. If the oil has been charged with phoſphorus at a boiling heat, a portion of this latter depoſits by cooling in octohedral cryſtals. Phoſphorized oil when diſtilled affords phoſphuretted hydrogen gas.

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[a] Mem. de l'Acad. 1795. p. 329.

Sulphur is eaſily and largely ſoluble in boiling oil: the compound has a thick ſomewhat viſcid conſiſtence, and a deep red colour, hence it was formerly named *ruby of ſulphur*. When highly charged with ſulphur at a boiling heat, it depoſits a part by cooling: if this takes place rapidly the ſulphur is in the form of needles, if more ſlowly it forms octohedral cryſtals.

Sulphurized oil has a ſtrong fetid odour, and when diſtilled gives out a large quantity of ſulphuretted hydrogen.

Moſt metallic oxyds are decompoſed by the fixed oils at a boiling heat: thoſe however that are commonly employed for this purpoſe are minium and litharge. If either of theſe ſubſtances ground to a very fine powder, be put in a kettle with a little water and ſome *fat* oil, and the whole be well mingled by conſtant ſtirring, it will be found that the oil when nearly at the temperature of boiling water, firſt abſtracts part of the oxygen from the oxyd, and then diſſolves pretty rapidly the oxyd itſelf. In conſequence of this the oil becomes thick and coloured, acquires a peculiar odour, and when cooled becomes opake, and of a ſoft paſty conſiſtence. By continuing the heat after the ſolution of the oxyd, till the water is compleatly driven off, the reſidue on cooling acquires nearly the conſiſtence of wax, and is known in pharmacy by the appellation of *plaſter*. If inſtead of fat oil, *drying* oil be made uſe of, the mixture cannot be made harder than ſtiff paſte. Deyeux[b] has ſhewn that the fat oils when previouſly mixed with mucilage, are exactly ſimilar in this reſpect to the drying oils. Plaſter is not ſoluble either in alcohol or water, in which reſpect it differs materially from the proper ſoaps, to which it has been compared by ſome chemiſts. If after the oil and litharge have combined together the water is poured off, inſtead of being diſſipated by a further continuation of the heat, and then evaporated conſiderably in a ſeparate veſſel, it will be found to have acquired a thick ſyrupy conſiſtence and a ſaccharine taſte. The diſcovery of this peculiar ſweet matter is due to Scheele, from whoſe experiments on the ſubject the following particulars are extracted.[c]

It is neither cryſtallizable nor ſuſceptible of fermentation: if prepared with perfectly freſh oil it appears to contain no lead, but if rancid oil has been made uſe of, it yields a precipitate of ſulphated lead with ſulphuric acid. If after being inſpiſſated it is ſtrongly heated, the vapours that ariſe will take fire on the application of a candle. By deſtructive diſtillation repeated two or three times at a temperature equal to that required for the volatilization of ſulphuric acid, it is decompoſed into brown empyreumatic oil, and a light ſpungy coal, carburetted hydrogen being probably given off at the ſame time. By repeated abſtraction with nitric acid it is at length converted into oxalic acid.

If the naturally drying oils are boiled upon a ſmall quantity of litharge without the intervention of water, they become thick and glutinous, and more drying than before. Not only the oxyds, but alſo aqueous ſolutions of the acetite of lead, as well as the ſulphat of zinc, are employed for this purpoſe.

The alkalies, both fixed and volatile, and the alkaline earths when perfectly cauſtic, act with energy upon all the fixed oils, but more eſpecially on the fat ones, forming with them Soaps of various qualities; for an account of which the reader is referred to that article.

The action of the ſtronger acids upon oils is very remarkable, on which account we ſhall treat of it with ſome minuteneſs.

The compound produced by the mutual action of fixed oil and ſulphuric acid, improperly called an acid ſoap, has been examined by Achard[d] with the following reſults. To prepare this compound, put 7 parts of concentrated ſulphuric acid into a porcelain mortar, and add drop by drop 8 parts of oil heated nearly to ebullition, taking care to ſtir the whole conſtantly during the proceſs: if the oil is added too quickly an effervеſcence takes place accompanied by the ſuffocating odour of ſulphureous acid, but this muſt be carefully avoided. The compound when recently prepared is of a black colour, and nearly of the conſiſtence of thick tar, but by waſhing thoroughly in 6 parts of diſtilled water the oil aſſumes nearly the appearance of brown wax: if it is ſtill acidulous to the taſte, repeat the waſhing in ſucceſſive ſmall quantities of water, till the laſt no longer exhibits any ſigns of uncombined acid. The oil becomes conſiderably heavier by this treatment, not unfrequently ſinking in water: it is ſolid and brittle, has a peculiar odour, is perfectly ſoluble in alcohol, and with water makes an opaleſcent mixture, which lathers like an infuſion of common ſoap. The watery ſolution exhibits the following phenomena. With ſemi-cauſtic potaſh it yields an opake coagulum, and being then moderately heated the oil melts into one maſs, which on cooling concretes into a brown waxy matter, entirely ſeparate from the aqueous fluid, from which cryſtals of ſulphated potaſh are depoſited by evaporation. Cauſtic ammonia produces no viſible change at firſt, but in a ſhort time cauſes the ſeparation of a coagulum that is reſoluble in an exceſs of alkali, but if waſhed and melted, exactly reſembles the precipitate by potaſh. Both magneſia and chalk produce a ſimilar coagulation of the oily part of the ſolution. A like decompoſition takes place by digeſtion with ceruſſe, with filings of iron or of zinc, with the acetites of lead and copper, with nitric, muriatic, and ſtrong acetous acids, with nitrat of potaſh and muriat of ammonia, but not with nitrat of ſoda, or muriat of ſoda. The coagulum in all theſe caſes aſſumes the appearance of yellow wax. When the acid ſoap is ſubjected to gradual diſtillation there firſt comes over a nearly inſipid phlegm, and then an oil more or leſs coloured and rancid, in proportion to the deepneſs of its colour, which congeals on cooling; there remains in the retort a little carbonaceous matter.

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[b] Ann. de Chem. xxxiii. p. 59.

[c] Eſſ. p. 364.

[d] Journ. de Phyſ. xvi. p. 411.

Nitric acid when cold and colourleſs acts but ſlowly on fixed oils, and the chief viſible effect produced is that of rendering them thicker than before. But if ruddy nitrous acid is made uſe of, a much greater and more rapid alteration takes place, a violent effervescence comes on, attended by a copious diſcharge of nitrous gas. If a mixture of concentrated ſulphuric and very high coloured nitrous acid be ſuddenly added, immediate combuſtion is for the moſt part the conſequence, particularly if the oil is either naturally drying or made ſo by either of the methods already deſcribed. Nitric acid abſtracted upon oil is decompoſed, and oxalic acid is the reſult. If nitrous vapour or nitrous gas are thrown up into an inverted jar containing oil, they are rapidly abſorbed, and the colour of the oil is changed to blue or green; after being put for a few hours in a cold place, the oil ſolidifies, and its colour becomes yellow or orange, a conſiderable diſengagement of azot takes place, and in the courſe of a few weeks it becomes nearly white and very ſtiff.[*]

Muriatic acid produces little change in any of the fixed oils, but oxymuriatic acid thickens and bleaches them, and cauſes them to paſs nearly into the ſtate of wax.

None of the neutral ſalts are capable of combining with oil, nor of decompoſing it at the common temperature, except the oxymuriat of potaſh: this mixed up in a metal mortar with a few drops of oil, and then ſtruck ſmartly with the peſtle, immediately detonates and takes fire.

Oil unites pretty eaſily with ſugar or ſimple mucilage, and in this ſtate is miſcible with water into a white emulſive liquor.

The drying oils when mixed with lamp-black, or with almoſt any very dry vegetable fibre, and put into a box or cloſe room, are very ſubject to undergo a rapid decompoſition attended by great heat, which on the admiſſion of freſh air, burſts into actual INFLAMMATION.

We ſhall terminate this article by ſome ſhort notices concerning the qualities and method of preparation of the principal fixed oils.

Olive Oil.

The fruit of the olive tree (Olea Europea) when ripe, is of a dark purple colour, and both in ſize and ſhape reſembles a long plum: it conſiſts of a nut or ſtone covered by a fleſhy pulp, in the latter of which are the cells that contain the oil: the interior nut alſo contains an oil, but of a bitter diſagreeable taſte. The fruit as ſoon as gathered is broken in a mill, care being taken to ſet the mill-ſtones at ſuch a diſtance as to avoid cruſhing the nut of the olive. The pulp thus prepared is put into bags made of ruſhes, and ſubjected to a moderate preſſure, by which a conſiderable quantity of a greeniſh ſemi-tranſparent oil is obtained, which from its ſuperior excellence is called virgin oil. The marc remaining after this firſt operation is broken to pieces, moiſtened with a little warm water, and again returned to the preſs; a mixture of oil and water flows out, which ſoon ſeparates ſpontaneouſly by reſt. This oil though inferior to the former, is ſtill of a very good quality and fit for the table. The marc being again broken to pieces, drenched with water, and fermented in large ciſterns, is for the third and laſt time ſubmitted to the full force of the preſs, by which a conſiderable quantity of oil is obtained, very valuable to the ſoap-boiler and other manufacturers. In ſome countries, particularly in Spain, the olives inſtead of being gathered by hand, are beaten down, by which the ripe and unripe are mixed together, to theſe alſo are added ſuch as have fallen of themſelves, and are therefore more or leſs decayed. Of this indiſcriminate collection a large heap is made, which ſoon begins to ferment; in this ſtate the olives are ground, and ſtrongly preſſed in the uſual manner, by which mode of proceeding a larger quantity of oil is indeed obtained, and with leſs trouble, but of a rank diſagreeable flavour, intolerable to any but thoſe who have from childhood been accuſtomed to it.

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[*] Prieſtley on Air. Method iii. p. 112, 136.

Recently drawn virgin oil has a bland almoſt mucilaginous taſte, with a ſlight but agreeable flavour: if expoſed to the air in an open bottle or caſk, a white fibrous and probably albuminous matter is depoſited, the ſupernatant oil becoming clear, and of a dilute yellow colour; the oil being poured off into a freſh veſſel, a ſecond depoſition takes place, after which the oil if put in clean glaſs vials, may be kept for a conſiderable time without alteration. If the oil is allowed to ſtand on the white matter, it becomes in a few weeks very rancid; and the common oil even when properly managed, cannot be preſerved in caſks longer than a year and a half, or two years at the fartheſt. The ſp. gr. of olive oil is = 0.9153; it boils at about 500° Fahr. and congeals at 36° Fahr. The readineſs with which it freezes renders it improper for lamps, eſpecially in cold countries; but by previouſly expoſing the oil in an open clear glaſs vial to the ſunſhine, it may be ſo far amended in this reſpect, as to continue fluid at 21° Fahr.[f] Olive oil is often ſophiſticated by poppy-ſeed oil, and thus is rendered ſomewhat drying, a property which the genuine produce of the olive never exhibits. In thoſe countries where it is produced it is employed in food, as butter is with us: the inferior ſorts are burnt in lamps, or made into ſoaps, for the moſt part of a finer quality than thoſe that are compoſed of animal oils. It is uſed in medicine ſometimes internally, but generally externally, combined with wax, litharge, &c. into cerates and plaſters.

Cornel Oil.

The only oil reſembling that from the olive, in being contained not in the ſeed but in the pulpy fruit of a vegetable, is cornel oil. The berries of this ſhrub (Cornus ſanguinea, *Linn.*) being collected when quite ripe, and then laid in heaps for a few days in order to mellow, are to be reduced to a pulp, and preſſed without heat in the uſual manner. By this treatment, from 22 lbs. avoir. may be obtained ſomewhat more than four wine pints of a fat ſomewhat viſcid oil, of a bright green colour, and equally deſtitute of any unpleaſant flavour as the beſt olive oil. When heated with nitric acid it is converted to a lemon-yellow butter or wax. By boiling with litharge it becomes drying; when ſpread thin on water and expoſed to the air for a month, it is converted into a white wax. It does not freeze ſo readily as olive oil, and laſts rather longer than this when uſed in a lamp.[g]

Almond Oil.

This is procured either from the ſweet or bitter almond. The almonds are firſt put into a coarſe hempen or hair ſack, and ſhaken violently, in order to detach, by rubbing againſt each other and the ſides of the ſack, the outer brown ſkin, which if retained is apt to give a bitter taſte to the oil: they are then bruiſed and made into a paſte, and preſſed in the uſual manner. 100 lbs. of almonds afford by the firſt expreſſion, 25 lbs. of oil, and from the marc when impregnated with the ſteam of hot water, may be procured 15 lbs. more of an inferior kind. Almond oil when freſh, is of a light greeniſh yellow colour, and is ſomewhat turbid, but by time it becomes clear and colourleſs: it is ſlightly ſweetiſh to the taſte, and has little or no odour. Its ſp. gr. is = 0.917. The degree at which it congeals is variouſly ſtated at 19° Fahr. and 8° Fahr.; the former probably relates to the freſh-drawn oil. The only difference between the oil from ſweet and that from bitter almonds is, that the latter may be kept the longeſt without growing rancid. On account of its high price, at leaſt in moſt of the countries of Europe, it is almoſt entirely reſtricted to medical uſes.

Poppy-ſeed Oil, or *Pink Oil.*

This oil is extracted by cold drawing from the ſeeds of the large white poppy (Papaver ſomniferum. *Linn.*) which is largely cultivated for this purpoſe in France, the Netherlands, and various parts of Germany. It is tranſparent and nearly colourleſs, and when well prepared has no other taſte or flavour than a ſlight one of nut-kernels. Its ſp. gr. is = 0.9288: it is one of the naturally drying oils, and like all of that claſs is frozen with difficulty; it may be cooled down to 0° of Fahr. without congealing. When employed in food it is ſcarcely to be diſtinguiſhed from olive oil, and indeed this latter is very commonly adulterated with it. As to the quantity of oil yielded by a given weight of the ſeeds, authors are by no means agreed, and much no doubt depends not only on the mode of extracting it, but alſo on the ſeaſon and country in which the ſeeds are produced: from 100 lbs. of freſh ſeeds, ſome ſtate the produce of oil at 25 lbs. and others at 58 lbs.

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[f] Sennebier, Ann. de Chem. xi. p. 93.

[g] Marguerон, in Ann. de Chem xxxviii. p. 174.

It is uſed both for food and in the compoſition of varniſhes, but is very unfit to burn in a lamp.

Linſeed Oil.

The ſeeds of the common flax, from which this oil is produced, conſiſt of a white kernel covered by a thin browniſh ſhell. As it is impoſſible to ſeparate the ſhell from the kernel, the entire ſeed muſt be ſubmitted to the preſs, but if thus treated without any previous preparation, the quantity of oil obtained is comparatively ſmall on account of a ſtrong mucilage that reſides in the ſhell, and abſorbs a large proportion of the oil as it is forced out of the kernel. For this reaſon, and becauſe the cold drawn oil is not ſo fit for the purpoſes to which linſeed oil is generally applied as that which is hot drawn, the following method is generally taken to deſtroy the mucilage before the application of the preſs. An iron veſſel like a ſand-bath, and capable of containing ſome buſhels, is fixed in a furnace: it is then filled with linſeed and heated by a moderate fire, care being taken to ſtir up its contents from time to time, that every part may be equally roaſted; at firſt there ariſes an abundance of aqueous vapour, which as the heat is increaſed is followed by denſe blackiſh fumes of a very nauſeous odour. The torrefaction being compleated, the paſte is preſſed in the mill in the uſual way.

The proportion of oil yielded by this ſeed is about 20 per cent: its ſp. gr. is =0.9403. It is not congealed except by a cold below 0° Fahr. its point of ebullition is about 600° of the ſame thermometer. The cold drawn oil has a high yellow colour, is very unctuous and unpleaſant both to the taſte and ſmell; by expoſure to the air and light it becomes drying. The hot drawn oil is of a high yellowiſh red or deep wine colour, it is ſtill more nauſeous than the former; it is of a thicker conſiſtence, and dries without much difficulty in the air, more eſpecially if it has been boiled with a little litharge. Linſeed oil is employed a little in medicine, but the great demand for it is in the coarſer kinds of painting, particularly ſuch as is not much expoſed to the weather, as floor cloths, &c.

Hempſeed Oil.

This oil is of a green colour and is ſtrongly impregnated with the peculiar odour of the plant. The proportion of oil that hempſeed affords is from 20 to 25 per cent. In its general properties, uſes, and mode of preparation it cloſely reſembles the preceeding.

Oils of Muſtard-ſeed, Cole-ſeed, Rape-ſeed, and Sunflower-Seed.

Theſe oils are leſs coloured and leſs highly flavoured than the two preceeding, they are very little liable to dry by expoſure to the air, which, together with their moderate price, induces a large conſumption of them by the wool-dreſſers in order to preſerve the wool from the attacks of moths and other inſects; and by the leather dreſſers.

Nut-Oil.

This is obtained chiefly by cold drawing from the kernels either of the walnut or of the hazle nut. In the warm climate of the South of Europe theſe fruits come to their full perfection, and will yield by proper management full half their weight of oil. Recent cold drawn nut oil is by many preferred to olive oil, on account of the exquiſite nut flavour which it retains: the hot drawn has an empyreumatic taſte, and is no longer fit for the table; it is however in high requeſt by the painter, as being eminently drying, much leſs coloured than linſeed oil, and capable of bearing the injuries of the weather better than any other oil.

Beech-nut Oil.

Several ineffectual attempts have been made to manufacture this oil with profit from Engliſh Beech maſt. Various cauſes have probably concurred to occaſion the failure, particularly the inexpertneſs in the method of extraction, and in all probability a real defect of oil compared to that contained in the beech nuts of France and the South of Germany. The following is the method adopted by ſome manufacturers, and appears upon the whole to be the beſt. The nuts when ſeparated from the outer prickly receptacle are paſſed through a mill, the ſtones of which are ſet ſufficiently wide to break off the outer ſhell without materially bruiſing the kernel, after which by means of the common winnowing machine the ſhells are got rid of. The decorticated nuts are then thrown into ſcalding water, and all thoſe that ſwim are rejected as being mouldy and worm eaten, and therefore communicating a bad taſte to the oil: the reſt are reduced to a pulp, and then cold drawn, when they will be found to yield 15 per cent. of a clear light coloured nearly inſipid oil, to the full as good as common olive oil. The marc being now ſlightly torrefied and again preſſed, will afford 12 per cent. more of an inferior oil, and the dry reſidue is an excellent food for cattle, much better than common oil cake.

Oil of Ben. Oleum Balani of the ancients.

This oil is procured by expreſſion from the decorticated ſeeds of the Guilandia Moringa, a tree that grows in Ceylon, Ethiopia, Egypt and Arabia. 100 lbs. of the ſeeds yield 23 lbs. of a yellowiſh limpid oil, inodorous, inſipid, and which does not become rancid by expoſure to the air. On this account it is much uſed by the Italians as the baſis of their perfumed oils, which are commonly prepared by filling a covered diſh with alternate layers of cotton ſoaked in Ben oil, and flowers of jaſmine, violet, orange, &c. after the diſh has been ſet in hot water, or in the ſunſhine for a few days, its contents are unpacked and the oil ſqueezed out of the cotton, which by this ſimple proceſs is found to be highly impregnated with the aromatic qualities of the flowers.

There are ſeveral other kinds of expreſſed oils employed in various countries as food, or in lamps, &c. but of which we ſhall only particularize the two following, as being ſpecimens of the vegetable butters.

Butter of Cacao.

This oil is procured from the chocolate nut, the fruit of the Theobroma Cacao. The nuts are firſt gently roaſted till the thin outer huſk ſhells off, and are then beaten up into a ſmooth thin paſte by the addition of eight times their weight of warm water. This mixture being then kept at a gentle boiling heat for ſome hours, a liquid oil riſes to the ſurface, which when the fire is withdrawn concretes into a ſebaceous matter of a grey colour, and amounting to about 45 per cent. of the entire nuts. This oil may be rendered nearly white by repeated waſhing in ſcalding water. It has little or no taſte, but retains for a long time the delicate flavour of chocolate, and appears to be the leaſt diſpoſed of any of the oils to become rancid. It is employed in America as an article of food, and in the compoſition of unguents and medicated ſoaps.

Palm Oil.

Many of the palms produce a hard nut like a date ſtone, but abounding in oil. Of theſe the two principal are the Cocos butyracea and Elæis guineenſis. The fruit when ripe is heaped up and ſlightly fermented in order in ſome meaſure to ſoften it; being then coarſely pounded it is macerated in hot water, and thus by degrees parts with its oil, which collects on the ſurface of the water, and by cooling concretes into a ſolid cake: it is purified by waſhing in hot water and is then fit for uſe. It has a light lemon yellow colour, little or no taſte, but a high odour and flavour like that of the Florentine iris: by long keeping it becomes rancid, and then is nearly white and almoſt without odour. It is largely uſed by the negroes in Africa and the Weſt Indies as food, and in Europe is employed in medicine, and in the compoſition of the beſt yellow ſoap.

OILS VEGETABLE, ESSENTIAL, or VOLATILE.

Theſe oils are ſo called becauſe they are evaporable at a moderate heat without decompoſition, and becauſe in them the odour or fragrance, or as it was called by the old chemiſts, the *eſſence* of vegetables reſides. They are not confined to any particular parts of a plant, but exiſt in minute cells diſtributed through the root, the wood, the bark, the leaves, the bloſſoms, and ſeeds. The part in which they occur leſs frequently than any other is the lobe or cotyledon of the ſeed, the peculiar ſeat of the fixed oil, while the huſk or cover of the ſeed is always more or leſs impregnated with volatile oil, the acrimony of which defends in ſome degree the rudiments of the young plant from the depredation of inſects.

The method of extracting the volatile oil differs for the moſt part very materially from thoſe which we have already deſcribed as practiſed for the fixed oils. Thoſe which are procured from the rinds of the lemon, the orange, and the bergamotte orange are the only ones capable of being obtained by expreſſion, which is performed in the following manner. A ſmall wheel with its circumference ſet with ſhort nails is put in motion, and a lemon or orange is applied to it till the whole of the yellow outer rind is thus raſped away: the raſpings fall to the bottom of the caſe in which the wheel turns, and when a ſufficient quantity is collected, are ſqueezed between two plates of glaſs; by this gentle preſſure the eſſential oil flows from the ruptured cells into any convenient veſſel placed to receive it, and undergoes no further preparation except that of being allowed to reſt till the water and other impurities have ſubſided.

A method analogous to that by which the vegetable butters are obtained is ſometimes practiſed in India for procuring that delicious and coſtly perfume the oil or *attar* of roſes. For this purpoſe a clean caſk or large glazed earthen jar is filled with roſe leaves carefully ſeparated from the calyxes, and ſpring water poured on juſt ſufficient to cover them: the veſſel with its contents is then ſet in the ſun for two or three days, and taken under cover during the night. At the end of the third or fourth day ſmall particles of yellow oil will be ſeen floating on the ſurface of the water, which in the courſe of a week will have increaſed to a thin ſcum: this is taken up by a little cotton tied to the end of a ſtick, and ſqueezed into a ſmall vial.

The oil contained in the fragrant bloſſoms of thoſe plants which have none in their other parts, as the violet, the mignonette, the jaſmine, the tuberoſe, the hyacinth, and all the ſcented liliaceous plants, &c. although exceedingly odorous, is ſo minute in quantity and ſo eaſily deſtroyed by heat as to be incapable of being extracted in any other way than by means of the oil of ben, as deſcribed in the laſt article. The fragrant oil may afterwards be ſeparated from the oil of ben in the following manner. Let a vial be half filled with a mixture of alcohol and perfumed oil in equal proportions, and ſhaken for a few minutes that every particle of each may come in contact with the other: then pour off the alcohol from the oil, which will be found to be nearly inodorous, having yielded its eſſential oil to the alcohol. Let this perfumed ſpirit be ſhaken again with ſucceſſive portions of oil, till the richneſs of its fragrance is not ſenſibly increaſed, and then pour it into a baſon containing two or three times its bulk of pure water: the water and alcohol will combine together, and the greater part of the eſſential oil will be liberated and will float at the top of the liquor, from which it may be ſcummed off by means of a little cotton. The liquor being afterwards ſubmitted to very gentle diſtillation, the firſt portion of ſpirit that comes over will be found to be ſtill very fragrant, and may be employed, mixed with freſh alcohol, in treating other portions of ſcented oil.

By far the greater number however of eſſential oils are obtained by direct diſtillation. If the ſubſtance to be treated is a freſh herbaceous plant it requires no previous treatment, but if it is a dried plant, a few hours maceration in water is adviſable; if a bark or wood is to be diſtilled it muſt be raſped or cut into ſhavings and macerated for ſeveral days. This being done, a tinned copper ſtill or alembic is to be charged with the ſolid materials cloſely rammed down, on which is to be poured juſt water enough to cover them, the head being then luted on and the refrigeratory filled with cold water, the fire muſt be lighted and ſo regulated as to keep the contents of the ſtill conſtantly ſimmering, but ſcarcely boiling. The ſteam being condenſed in the worm will form a ſmall ſtream of water, and is to be collected in proper veſſels till it comes off nearly inſipid and inodorous, when the diſtillation is to be ſtopped. The firſt part of the produce being turbid from ſuperſaturation with eſſential oil is to be kept for ſome hours in a cold place, during which time the exceſs of oil will ſeparate from the water, and either float on its ſurface or ſink to the bottom, according to its ſpecific gravity. The compleat ſeparation of the oil from the diſtilled water is effected by a very ſimple inſtrument called the Italian recipient, (deſcribed in the appendix) and the whole of the water drawn off in the firſt diſtillation is to be employed as far as it will go in the next, inſtead of plain water, by which it is manifeſt that the produce of oil in the ſecond diſtillation will exceed that of the firſt, (other circumſtances being equal) by all the quantity held in permanent ſolution by the water of the former proceſs. Hence it is manifeſt that by this mode of proceeding, the amount of oil yielded by equal quantities of the ſame ſubſtance will form a conſtantly increaſing ſeries, till the whole of the water drawn off by each diſtillation is compleatly ſaturated with oil. This accounts in ſome degree for the great difference in the proportions of oil obtained by different chemiſts from the ſame plants; for as Bindheim has ſatisfactorily ſhown, it is not till the ſeventh, or even in ſome caſes the tenth diſtillation that the produce of oil attains its *maximum*.

It is not only from the odorous vegetables themſelves that eſſential oil may be procured, but alſo from ſuch of the immediate products of vegetation as poſſeſs any odour; ſuch are the balſams and many of the reſins and gum reſins. The proceſs to be followed is diſtillation with water and preciſely the ſame ſubſequent treatment as we have already deſcribed.

The peculiar odour of vegetables, when not in a ſtate of decompoſition, depending on the volatile oil that they contain, it will be obvious that the odours of the oils themſelves muſt be equally various and therefore incapable of being deſcribed. The taſte of all of them is exceedingly hot and pungent, but in ſome, particularly the oil of peppermint, is followed by a remarkable ſenſation of coldneſs: this however is merely a nervous ſenſation, the thermometrical temperature undergoing no change. The acrimony of ſome of the oils, as the oil of cloves, is ſo great as actually to deſtroy the outer ſkin of the tongue and of other ſenſible parts. The conſiſtence of the eſſential oils is very various: ſome being as limpid as water, while others are thick and glutinous like the expreſſed oils. A ſlight degree of cold is ſufficient for their congelation, at which time they aſſume the appearance of cryſtalline plates, which however muſt not be confounded with the priſmatic cryſtals that moſt of them depoſit by long expoſure to the air. The colours of eſſential oils are various; ſome are blue, others green, but the uſual colour is light yellow verging more or leſs by long keeping to reddiſh brown.

Eſſential oil is compleatly volatile without decompoſition at a heat leſs than that of boiling water; (hence if a few drops are ſpread on a piece of paper and then held for a minute or two before the fire, any ſophiſtication with expreſſed oil may be detected by the greaſe ſpot that will remain after the volatile oil has been entirely exhaled). It may however be detained in a higher heat by mechanical mixture with dry clay or ſand, and then it undergoes a partial decompoſition, carburetted hydrogen being given out and a little charcoal remaining in the receiver: the undecompoſed reſidue if ſubjected three or four times ſucceſſively to ſimilar treatment will be entirely deſtroyed.

Eſſential oils are highly combuſtible; they take fire on the application of an ignited body or by the electric ſpark, and burn with a large white flame and a denſe black ſmoak; a larger proportion of oxygen is required for their combuſtion than of the other oils, and a greater quantity of water is produced.

The eſſential oils, eſpecially the more volatile of them, deoxygenate atmoſpheric air very compleatly, as was firſt aſcertained by Prieſtley, which in part at leaſt accounts for the uneaſy ſenſations experienced by moſt perſons when in a cloſe newly painted room. In proportion to the oxygen abſorbed the oil becomes thick and coloured, more eſpecially if it is at the ſame time expoſed to the ſun, and at length nearly loſes its peculiar odour and approaches in conſiſtence to a ſoft reſin. In thoſe oils that are naturally thick a change of another kind takes place: a weakly acidulous water is produced and priſmatic cryſtals are depoſited, the reſidue of the oil becoming in the mean time concrete. Theſe cryſtals, which have been occaſionally miſtaken for camphor, are ſlightly ſoluble in hot water, and more ſo in alcohol, to which they communicate the property of reddening vegetable blues: when gently heated they melt and cryſtallize in needles by cooling; when treated by the blowpipe they evaporate, but do not inflame: from theſe characters they have been conſidered as an acid very analogous to the benzoic. It appears from the experiments of Margueron [h] that ſome oils when expoſed to a freezing mixture undergo the ſame change: at the moment of congelation a portion of highly odorant gas is diſengaged, a watery acid is produced and cryſtals are depoſited. Some eſſential oils however afford real camphor by evaporation, as Prouſt has ſhown, and as the reader will find fully detailed under the article CAMPHOR.

Oil that by long keeping in a half-cloſed bottle has become thick and nearly ſcentleſs, may be rectified by rediſtilling it with water and ſome of the freſh vegetable from which it was originally extracted, and this was often cited as a proof that the ſubſtances called eſſential oils were in reality compounds of reſin and the *ſpiritus rector*, or aromatic principle. But preciſely the ſame effect may be produced by means of alcohol or ſtill more readily by ether. This curious and important fact was firſt ſtated by De Roover [i], from whoſe experiments it appears that if thick ſpoiled oil be mixed with $\frac{1}{16}$ of ſulphuric ether for a few days and then diſtilled with pure water, more than half the oil will come over perfectly limpid and poſſeſſed of its peculiar odour, while the remainder will be left behind in the ſtill in the ſtate of a dark coloured reſin. The united weights of the diſtilled oil and reſin exceed that of the original oil, whence it is probable that the ether actually combines with part of the oil, and probably by ſupplying it with hydrogen, reſtores to it the liquidity and odour which it poſſeſſed at firſt. It is to be regretted that M. De R. did not follow up his experiments by treating the reſinous portion with freſh quantities of ether, ſo as to aſcertain whether it was poſſible to convert it in part or entirely into volatile oil as at firſt.

Eſſential oil is ſparingly ſoluble in water, from which it may be ſeparated by diſtillation, but is taken up much more abundantly by alcohol; this ſolution however is decompoſable by water, the greateſt part of the oil being ſeparated.

Both ſulphur and phoſphorus are ſoluble in eſſential oils equally well as in the fixed and with nearly the ſame phenomena: phoſphorized oil is luminous in the dark, has a fetid odour, and gives out phoſphuretted hydrogen by diſtillation: ſulphurized oil is of a yellow or brown colour, and gives out on diſtillation ſulphuretted hydrogen; it is often called *balſam of ſulphur*.

The ſtronger acids act more vigorouſly on the eſſential oils than they do even on the fixed.

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[h] An. Chim. xxi. 174.

[i] Nich. Journ. 8vo. vii. p. 68.

Sulphuric acid cauſes a ſtrong efferveſcence and evolution of heat, the oil is rendered thick and brown, and water is produced. Highly concentrated and fuming nitrous acid if poured ſuddenly on theſe oils occaſions an inſtantaneous inflammation; but if ſomewhat diluted and added drop by drop a conſiderable efferveſcence takes place, accompanied by the diſengagement of nitrous gas; the oil becomes thick and yellow and at length aſſumes the appearance of a ſoft reſin: by waſhing in repeated portions of water all the acid is got rid of. The reſinous matter thus procured is inſoluble in water, but very ſoluble in alcohol, to which it gives a bright wine colour and a bitter ſub-aromatic flavour; it is inflammable and exhibits moſt of the other properties of true reſin.

The action of muriatic acid upon the volatile oils has been but little examined. When thrown in a gaſſeous form into oil of turpentine it blackens it and cauſes a precipitation of a ſpecies of CAMPHOR on ſubſequent waſhing with water. Oxymuriatic acid thickens the volatile oils and brings them nearly to the ſtate of reſins with little or no colour.

The alkalies combine though imperfectly and not without difficulty with the eſſential oils, forming a claſs of SOAPS, of which we ſhall ſpeak more at large hereafter.

We ſhall cloſe this article by the following liſt of the principal vegetables that afford eſſential oil, and of the proportions obtained from a given weight of the materials, premiſing that conſiderable allowances are to be made for difference of climate, of dryneſs in the plants, and other cauſes of uncertainty.

Name and ſtate of the Vegetable.	*Quantity.*	*Amount of Oil.*	*Authority.*
Aniſe, ſeeds	16 lbs.	7 oz.	Beaumé
—— ditto	1 lb.	2 drachms	Neumann
Cajeput, ſeeds	1 lb.	15 grs.	Dehne
Camomile, flowers	82 lbs.	18 gros.	Beaumé
—— ditto	30 lbs.	1¼oz.	Dehne
Capivi, balſam	1 lb.	6 oz.	Hoffmann
Carraway, ſeeds	6 lbs.	4½oz.	Beaumé
—— ditto	1 cwt.	83 oz.	Lewis
Cedar, wood	1 lb.	2 drachms	Margraff
Cinnamon, bark	12½ lbs.	1 gros.	Beaumé
—— ditto	1 lb.	2½ſcruples	Neumann
—— ditto	4 lbs.	6 drachms	Lemeri
—— ditto	3 lbs.	4 drachms	Cartheuſer
Cloves	1 lb.	2¼oz.	Cartheuſer
Ditto	2 lbs.	5 oz.	Hoffmann
Coriander, ſeeds	164 lbs.	5 oz. 4 gros.	Beaumé
Cubeb, ſeeds	12½ lbs.	2 oz. 1 gros.	
Cummin, ſeeds	20 lbs.	12 oz.	
—— ditto	1 buſhel	21 oz.	Lewis
Dill, the freſh plant	60 lbs.	1½oz.	Beaumé
—— ſeeds	4 lbs.	2 oz.	
—— ditto	4 lbs.	2 oz.	Lewis
Elecampane, freſh root	12 lbs.	½gros.	Beaumé
—— ditto	12 lbs.	3½drachms	Dehne
Fennel, ſeeds	75 lb.	30 oz.	Beaumé
—— ditto	1 lb.	8 ſcruples	Neumann
Feverfew, in flower	56 lbs.	1½oz.	Beaumé
Ginger, root	1 lb.	1 drachm	Lewis
Hyſſop, flowers	20 lbs.	6 gros.	Beaumé
—— leaves	2 cwt.	6 oz.	Lewis
Juniper, berries	10 lbs.	4 gros.	Beaumé
—— ditto	48 lbs.	6 oz.	Dehne
—— ditto	8 lbs.	3 oz.	Hoffmann, Cartheuſer
Lavender, flowers	80 lbs.	1 lb. 9 oz.	Beaumé
—— ditto	48 lbs.	12 oz.	Lewis
—— ſtalks and flowers	13½ cwt.	60 oz.	

Name and ſtate of the Vegetable.	*Quantity.*	*Amount of Oil.*	*Authority.*
Marjoram, whole plant & in flower	150 lbs.	15 oz.	Beaumé
Ditto	85 lbs.	3¼ oz.	Lewis
Myrtle, leaves	10 lbs.	1 gros.	Beaumé
Pepper Black, ſeeds	1 lb.	2½ drachms	Neumann
———— ditto	2 lbs.	6 drachms	Lewis
Peppermint, whole plant	4 lb.	3 drachms	Lewis
———— in flower	1 cwt.	2½ to 6 oz.	Original communication
Rhodium, wood	80 lbs.	2 oz.	Beaumé
———— ditto	1 lb.	3 drachms	Neumann
Roſes, entire flowers	80 lbs.	1½ drachm	Polier
———petals	1 cwt.	4 drachms	Tachenius
———ditto	1 cwt.	1 oz.	Homberg
Roſemary, leaves	24 lbs.	1 oz.	Beaumé
———— in flower	1 cwt.	8 oz.	Lewis
Rue, whole plant between flower and ſeed	21 lbs.	1 gros.	Beaumé
Ditto	72 lbs.	3 oz.	Lewis
Ditto ſeeds	10 lbs.	2 oz.	Beaumé
Saffron	1 lb.	5 ſcruples	Cartheuſer
Sage, in flower	48 lbs.	from 2½ to 3 oz.	Beaumé
—— ditto	27 lbs.	6 drachms	Lewis
Sanders Yellow, wood	1 lb.	2 drachms	Cartheuſer
Saſſafras, wood	60 lbs.	from 12 oz. to 13½ oz.	Beaumé
————ditto	6 lbs.	2 oz.	Neumann
Savine, whole plant	23 lbs.	4½ oz.	Beaumé
——— bark	29 lbs.	9 oz.	Dehne
Spearmint, whole plant	96 lbs.	1 oz.	Beaumé
———— in flower	6 lb.	4½ drachms	Lewis
Tanſy, in flower	72 lbs.	1½ oz.	Beaumé
Thyme, in flower	2 cwt.	5½ oz.	Lewis
——— Lemon, in flower	98 lbs.	2½ oz.	
——— dry	3½ lbs.	1½ drachm	
Wormwood, the freſh plant	712 lbs.	20 oz.	Beaumé
———— the dry leaves	18 lbs.	1½ oz.	Lewis

The eſſential oils are employed in medicine, in perfumery, and in the compoſition of varniſhes and of oil paints; to which latter purpoſe the oil of Turpentine is almoſt entirely appropriated.

Oils Vegetable Empyreumatic.

Almoſt every vegetable matter when ſubjected to dry diſtillation affords a quantity of oil, varying according to the nature of the ſubſtance, and the circumſtances of the experiment. The oil thus produced has not been ſubjected to very accurate examination, yet may be deſcribed as poſſeſſing the following characters. Its colour is yellowiſh-red paſſing into blackiſh-red, it has a ſtrong odour, and an acrid empyreumatic taſte; it is more volatile than the fixed oils, but leſs ſo than the proper eſſential ones: by re-diſtillation with a little water it comes over nearly colourleſs, and more volatile than before, though ſtill poſſeſſed of much of its empyreumatic flavour. Two of theſe oils namely, tar and birch oil, are of conſiderable importance; for an account of the firſt we ſhall refer the reader to the article Turpentine. The latter is prepared in Ruſſia, by charring birch wood in a cloſe oven, the watery acid and oil are collected in a large receiver, and the latter product being the lighеſt is ſkimmed off from the ſurface of the water. This oil has a peculiar ſcent, and is ſaid to drive away worms and other inſects, on which account it is uſed in the dreſſing of Ruſſia leather, to which it communicates thoſe properties that render it ſo much eſteemed by the binders of books.

Oils Animal, Fixed.

All animals except thoſe included in the claſs of inſects, contain oil; the quantity however of which, as well as the ſituation which it principally occupies in the body, is ſubject to conſiderable variety. In all caſes it is contained in peculiar receptacles of cellular membrane; but theſe receptacles in quadrupeds are for the moſt part but ſparingly diſperſed among the muſcular fibre, are more abundant in the bones, and moſt ſo of all in the cavity of the abdomen, and eſpecially attached to the kidneys. The hog however is an exception to this, the principal part of his fat being depoſited between the ſkin and the muſcles. In birds the chief ſeat of the oil is immediately below the ſkin, and in water-fowl it is particularly ſecreted by a collection of glands in the rump. In the warm blooded fiſh, as the whale, the oil is chiefly contained in the head and jaw-bones, and is interpoſed in vaſt abundance between the ſkin and the muſcular fleſh. In the cold blooded fiſh it is contained in the liver, as in the ſhark, the cod, and the ling; or is diſperſed through the whole body, as in the ſprat, the herring, and pilchard.

While the fat remains in the living body it is always in a fluid or ſemi-fluid ſtate, but after it has been extracted and is expoſed to the common temperature, a remarkable difference in its conſiſtence is obſerved. The oil or fat inveſting the kidneys of quadrupeds is called ſuet or tallow, and is the moſt ſolid and hardeſt of any; the next in hardneſs is the fat of the bones, and that in which the muſcles are imbedded is the next in degree; the fat of the hog (called lard) is the leaſt ſolid. The fat of birds is ſeldom ſo ſolid as hog's lard, and in many ſpecies is actually fluid. The fat or oil of fiſh is almoſt always fluid at the common temperature. Beſides the above varieties of animal oil, there is yet another contained in the yolk of eggs, and which may be extracted by ſimple preſſure after the yolk has been coagulated by heat.

Animal oil in its pureſt ſtate is obtained by cutting freſh ſuet into ſhreds and liquefying it in boiling water, and then paſſing it through a piece of thin gauze, in order to ſeparate the cellular membrane. When thus purified it is of a yellowiſh-white colour, moderately hard, of a mild taſte, and nearly deſtitute of odour or flavour: it is combuſtible, like the fixed vegetable oils, and agrees alſo with theſe in the changes produced upon it by the alkalies and other chemical re-agents. All the animal oils however belong to the claſs of unctuous or fat oils, none of them being either drying in itſelf or capable of becoming ſo by means of litharge or other ſubſtances.

When fat is expoſed to dry diſtillation, as ſoon as it acquires the temperature of about 400° it emits a white acrid and diſagreeable vapour; as the heat increaſes ſome of the oil comes over into the receiver, and what remains in the retort acquires a blackiſh tinge; empyreumatic, acetous, and SEBACIC acids, then make their appearance, together with carburetted hydrogen and carbonic acid of a moſt remarkably offenſive odour. This circumſtance ſhews that there is a real difference between animal and vegetable oils, though it has not yet been pointed out by chemical analyſis. The coarſer kinds of animal oil being extracted by means of putrefaction and a ſtrong heat, poſſeſs a much more diſagreeable odour than any of the vegetable oils, and when rancid diſengage ammonia by the action of the fixed cauſtic alkalies, in which alſo they differ from the latter.

The fiſh oils when rancid, and from the mode of their extraction they never are otherwiſe, are for the moſt part thick and glutinous, which in ſome meaſure diſqualifies them for burning and for ſome other uſes to which they are applied. Many attempts, for the moſt part without ſucceſs, have been made to bring them to a better ſtate, but as appears from the experiments of Mr. Doſſie,[k] they may be conſiderably improved by means of fixed alkali and chalk, by which the albumen and gluten are thrown down, and the ſupernatant oil after due reſt may be poured off in a fluid ſtate, and very ſenſibly amended both in conſiſtence, in odour, and in fitneſs for burning.

Animal oils are ſubſtances of great economical importance. They are uſed as food, and in medicine as the baſe of various unguents: they largely employed in the manufacture of ſoap, and for burning either in lamps or in the form of candles.

ANIMAL OIL VOLATILE, or Dippel's Oil.

As in the vegetable kingdom oil is produced by the deſtructive diſtillation of various ſubſtances that contain none in their natural ſtate; ſo it is with reſpect to the animal kingdom. If albumen, or gluten be diſtilled at a dry heat, there ariſes together with the ammonia, and carburetted hydrogen, a quantity of fetid black oil; this was made the ſubject of various experiments, firſt by Dippel, a chemiſt of Berlin, and afterwards by Rouelle. From the concurrent labours of theſe enquirers it appears that of this oil is rectified by three ſucceſſive diſtillations from the ſurface of water, or by a greater number without water, it becomes at length quite colourleſs and tranſparent; it has a powerful but ſomewhat aromatic odour, and is nearly as light and volatile as ether. It contains a little ammonia, and hence changes the colour of ſyrup of violets green, it is ſparingly ſoluble in water, and largely ſo in oils, ether, and alcohol. It combines both with acids and alkalies into imperfect ſoaps; it is very inflammable, and like the vegetable eſſential oils, may be ſet on fire by ſtrong nitrous acid. If expoſed even to the light it is partly decompoſed, loſing its tranſparency, and becoming of a brown colour. It was formerly employed in medicine, but is now wholly diſuſed.

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[k] Phil. Mag. xv. p. 105.

OIL MINERAL, or *Petroleum*. See BITUMEN.

OIL OF WINE. See ETHER.

OIL OF VITRIOL. See SULPHURIC ACID.

OIL OF TARTAR, *per deliquium*. See CARBONAT OF POTASH.

OISANITE. See ANATASE.

OLEFIANT GAS. See CARBURETTED HYDROGEN.

OLIVE OIL. See OILS VEGETABLE FIXED.

OLIVIN. *Volcanic Chryſolite. Peridot granuliforme.* Hauy.

Its colour is between aſparagus and olive-green, but by expoſure to the weather it becomes yellowiſh-brown. It occurs imbedded or diſſeminated in baſalt, and ſometimes in rounded pieces, alſo, though rarely, in ſmall rectangular priſms. Internally its luſtre varies between glimmering and ſhining, and is vitreous paſſing into reſinous. Its fracture is more or leſs imperfectly conchoidal, paſſing into ſplintery and uneven. Its fragments are indeterminately ſharp-edged. When in large pieces it exhibits granular diſtinct concretions. It varies from ſemi-tranſparent to tranſlucent. It is hard, but leſs ſo than quartz; it is brittle and eaſily frangible. Sp. gr. 3.22 to 3.26. It is nearly infuſible before the blow-pipe without addition; and loſes its colour by digeſtion in nitric acid. It has been analyſed by Klaproth with the following reſult:

	48.	to	52	Silex
	37.	—	38.5	Magneſia
	0.25	—	0.20	Lime
	12.5	—	12.	Oxyd of iron
	97.75			
Loſs	2.25			
	100.			

It occurs only in proper baſalt, and not in any other rock of trap formation. It is very eaſy of decompoſition, to which circumſtance many baſalts owe their porous texture. It is found very abundantly in Bohemia and other parts of Germany, alſo in France, Britain, Norway, and Sweden.

OOLITE. See LIMESTONE.

ONYX. See CHALCEDONY.

OPAL.

Of this mineral there are the four following ſubſpecies.

1. Subſ. NOBLE OPAL. *Edler Opal*, Wern. *L'Opale noble*. Broch.

Its colour is milk-white, or pearl-grey, and when held between the eye and the light is pale roſe-red and wine-yellow: by reflected light it exhibits, as its poſition is ſlightly varied, the cleareſt and moſt beautiful irideſcent colours, particularly verdegris and emerald-green, gold-yellow, fire-red, bright-blue, and pearl-grey; all theſe tints are often exhibited in the ſame ſpecimen, but when only one colour is preſent the green is the moſt eſteemed. It occurs in maſs, diſſeminated and in ſmall veins. Its internal luſtre is vitreous and brightly ſhining. Its fracture is conchoidal. Its fragments are indeterminate ſharp-edged. It is moderately tranſlucent paſſing to ſemi-tranſparent, and even tranſparent. It is moderately hard and very brittle. Sp. gr. 2.114.

Before the blow-pipe it crackles and flies, and becomes of an opake white, but does not melt. It is compoſed, according to Klaproth, of

90	Silex
10	Water
100	

It occurs diſſeminated in clay porphyry. It was formerly found near Freyberg in Saxony, but is at preſent met with only at Cſcherwenitza, near Kaſchau, in Upper Hungary.

It is the moſt beautiful of the gems, and among the Eaſtern nations is in particularly high eſtimation. In Europe its value though conſiderable, is inferior to that of the other gems from its ſoftneſs and liability to ſplit on a ſudden change of temperature. It is chiefly employed in necklaces, and ear-rings, and finger-rings.

The moſt beautiful varieties are called oriental opal, but there is no ſatisfactory evidence to ſhew that this ſubſtance has ever really been found in the Eaſt.

Some varieties of opal, from expoſure to the weather, are dull and opake, probably in conſequence of having loſt part of their water; but by immerſion in this fluid, their minute pores become again filled, and they then exhibit the uſual play of colours. Such ſtones are called hydrophanes, and are in high eſtimation.

The moſt beautiful opals known are in the Imperial cabinet of Vienna : one is a piece about five inches long, and two and a half in diameter : another is of the ſhape and ſize of a hen's egg. Both are remarkably rich and ſplendid.

2. Subſp. Common Opal. *Gemeiner Opal,* Wern. *L'Opale commune,* Broch.

Its colour is greyiſh, greeniſh, yellowiſh or milk-white, hence it paſſes into apple green, honey and wax-yellow, and ſometimes, though rarely, into tile red, or fleſh red. The milk white variety appears by tranſmitted light of a wine yellow. It occurs maſſive, diſſeminated, and in angular pieces. Its luſtre internally is between vitreous and reſinous, and is bright ſhining. Its fracture is conchoidal. Its fragments are indeterminately angular and ſharp-edged. It varies from tranſlucent to tranſparent. It is moderately hard, brittle, and eaſily frangible. Sp. gr. 1.95 to 2.01.

It is infuſible before the blow-pipe without addition. Two varieties, one from Koſemutz and the other from Telkobanya, have been analyſed by Klaproth with the following reſults.

	Koſem.		Telkoban.
Silex - -	98.75	—	93.5
Alumine -	0.1	—	0
Oxyd of iron	0.1	—	1.
Water - -	0.	—	5.
	98.95		99.5

It occurs chiefly in porphyry; but alſo in granite, gneiſs, amygdaloid, and ſerpentine.

The green variety is found at Koſemutz in Sileſia, where it accompanys chryſopraſe in a bed of ſerpentine. In Iceland it alternates with chalcedony. It is alſo met with in various parts of Saxony and Bohemia, near Florence in Italy, Telkobanya in Hungary, in the North of Ireland, in Cornwall, in Brittany, and in the Faroe iſlands.

Several of the varieties of common opal as well as of the noble opal, are hydrophanous.

3. Subſp. Semi-Opal. *Halbopal.* Wern. *La Demi-Opale.* Broch.

Its uſual colours are yellowiſh, greeniſh, and milk-white, alſo aſh-grey, and greyiſh-black, apple-green, olive-green, honey-yellow, yellowiſh-brown, and cheſnut-brown. Its colours are more dull and muddy than thoſe of common opal, and they often occur in ſpots, bands, and clouds. It occurs maſſive, diſſeminated, tuberous, reniform, botryoidal and ſtalactitic. Internally it is gliſtening or ſhining. Its fracture is imperfectly flat conchoidal, verging on even. Its fragments are indeterminately angular ſharp-edged. It is more or leſs tranſlucent, is moderately hard, brittle, and eaſily frangible. Sp. gr. 2.54.

It is infuſible before the blow-pipe without addition. Two varieties, the one from Telkobanya, and the other from Menil Montant, have been analyſed by Klaproth, with the following reſults.

	Telkob.		Menil.
Silex - -	43.50	—	85.5
Alumine -	0.	—	1.
Oxyd of iron	47.	—	0.5
Lime -	0	—	0.5
Water -	7.5	—	11.0
	98.0		98.5

It occurs in veins in porphyry and amygdaloid, and in metalliferous veins in granite and gneiſs. It uſually accompanies common opal, and is found in the ſame places with it. Foſſil teeth alſo are occaſionally found penetrated by this mineral.

4. Subſp. Wood Opal. *Holzopal.* Wern. *Opal Ligniforme.* Broch.

Its colours are greyiſh and yellowiſh-white, alſo ochre-yellow, yellowiſh-brown, aſh-grey, and greyiſh-black. It occurs in large pieces, which have the form and texture of wood. Internally it has a gliſtening ſomewhat reſinous luſtre. Its croſs fracture is conchoidal, but its longitudinal fracture is broad ſplintery. Its fragments are indeterminately angular ſharp-edged. It is tranſlucent, moderately hard, and eaſily frangible. Sp. gr. 2.6.

It appears to be wood penetrated with opal, and is found near Schemnitz, and at Telkobanya in Hungary.

ORPIMENT. See Arsenic.

ORPIMENT NATIVE. See Arsenic, Ores of.

ORES.

An ore is a metal in the ſtate in which it exiſts in the earth. It may be either native, that is, pure and uncombined with any other ſubſtance, or alloyed with another metal, or in the ſtate of an oxyd, or a ſulphuret, or a carburet, or of a metallic ſalt. It is alſo mixed in almoſt every caſe with various earthy minerals. For a particular deſcription of the ores of each metal, of their analyſis, and the methods purſued in their reduction, ſee the firſt, ſecond, and third ſections, in the account of each metal.

OSMIUM. See Platina.

OXALIC ACID. *Sauerkleeſaure.* Germ.

This acid is found frequently but not abundantly native, in various combinations, and it is alſo produced by the mutual action of the nitric acid upon a vaſt number of vegetable and animal ſubſtances. It is found native in a few acid vegetable juices, and in tolerable abundance in the expreſſed juice of the *ſorrel* plant (Oxalis Acetoſella. *Linn.*) naturally united with a quantity of potaſh not ſufficient for compleat ſaturation, forming an acidulum which has long been prepared for culinary and medicinal purpoſes in ſome parts of Europe, and ſold as the *Eſſential Salt of Sorrel,* long before its real nature was diſcovered. This acid is found in ſome ſpecies of urinary calculi.

The oxalic acid is artificially prepared by boiling a ſufficient quantity of nitric acid with a variety of vegetable and animal ſubſtances, ſuch as ſugar, mucilage, alcohol, ſilk, animal jelly, &c. &c. and many of the other vegetable acids (the acetous excepted) are convertible into the oxalic by the action of the nitric acid.

The oxalic acid as artificially prepared, was firſt diſcovered by Bergman, who has given a very valuable eſſay on the ſubject. This eminent chemiſt prepared it by diſtilling nitric acid from ſugar, and hence he termed it the *Acid of Sugar.* But as the acid of the native ſalt of ſorrel was ſoon after diſcovered by Scheele to identical with the acid of ſugar, the term *Oxalic Acid* has been more commonly adopted, and the combinations of this acid with the various baſes, have been termed *Oxalats.*

This acid is prepared from ſugar, very ſimply and eaſily by the following proceſs: put a ſmall quantity of white ſugar into a tall glaſs matraſs, with a narrow neck, add thereto ſix times its weight of concentrated nitrous or nitric acid, of moderate ſtrength, apply heat, and bring it gradually to boil, during which the ſugar ſpeedily diſſolves in the acid, and then decompoſes it with evolution of abundance of nitrous vapour. Continue the boiling for about ten minutes, then ſet the liquor by to cool, when it will depoſit regular cryſtals of oxalic acid. Evaporate the remaining liquor conſiderably, and by cooling another crop of cryſtals may be procured, and ſometimes a third. Rediſſolve all the cryſtals in as much water as will take them up when boiling, and by cooling ſlowly the cryſtals will again ſeparate in a more regular form, and freed from the adhering nitric acid. Dry theſe cryſtals on blotting paper, and they are the pure oxalic acid. A retort and receiver may be uſed for the proceſs inſtead of a matraſs, when it is an object to ſave the ſuperfluous nitrous acid. About 58 parts of oxalic acid may thus be obtained from 100 of ſugar.

The oxalic acid when in a regular form, cryſtallizes in four-ſided priſms, the faces of which are alternately broad and narrow, and terminating in dihedral ſummits. Theſe cryſtals do not deliqueſce, but by expoſure to the air they fall into a white powder.

This acid has a very pungent, and when diluted, a very grateful ſourneſs. The cryſtals diſſolve in their own weight of boiling water, and twice their weight of cold water.[a] The ſpecific gravity of a cold ſaturated ſolution is about 1.06. This acid has all the common properties of acids, of changing vegetable colours, and forming neutral ſalts with the alkaline, earthy, and many metallic baſes. It alſo forms acidula with all the alkalies, when the proportion of acid predominates.

This acid, like all the other vegetable acids, is decompoſed, and its acid properties deſtroyed by heat, more or leſs compleatly in proportion to the degree of heat. If heated in a retort with a gentle fire the water of the cryſtals firſt comes over, amounting to about $\frac{3}{10}$ of the whole, and the acid fuſes. On encreaſing the fire, the acid grows brown, and part of it is ſublimed as a white ſaline cruſt, but the greater part is reſolved into carbonic acid, and carburetted hydrogen, which come over in large quantity, having a pungent empyreumatic ſmell. The reſidue in the retort entirely burns away in the open air, without leaving any aſh.

Alcohol when boiling readily diſſolves ſomewhat more than half its weight of oxalic acid. On cooling, a ſmall portion is depoſited in ſmall ſcaly cryſtals, but the greater part remains in ſolution. The alcoholic ſolution when heated yields a portion of alcohol holding ſome of the acid diſſolved, and alſo a very ſmall quantity of an imperfect ether.

Sulphuric ether diſſolves oxalic acid, though with difficulty.

Sulphuric acid heated upon the oxalic blackens it, and the two ſubſtances are mutually decompoſed in part.

The nitrous or nitric acid readily diſſolves the oxalic, and if the former is in ſufficient quantity, and the mixture long boiled, much nitrous vapour is given out, no oxalic acid is found in the liquor, but the whole is converted into carbonic acid and water.

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[a] Bergman, on the Acid of Sugar.

The muriatic and acetous acids ſimply diſſolve the oxalic, but do not decompoſe it.

The compoſition of this acid according to Fourcroy and Vauquelin, is 77 *per cent.* of oxygen, 13 of carbon, and 10 of hydrogen, ſo that it appears to be one the moſt oxygenated of all the known acids.

Before we proceed to deſcribe the ſalts which it forms with the different baſes, ſome obſervations may be added on the circumſtances of its formation.

The oxalic acid is found but rarely native, but is readily produced by the action of nitrous acid on almoſt every ſoluble vegetable matter, and moſt animal matters. During this action the nitric acid is obviouſly decompoſed, and much nitrous gas given out, and hence the product muſt contain much of the oxygen which the nitric acid parts with. But it appears that the formaation of oxalic acid is not in any caſe a ſimple oxygenation of carbon and hydrogen, but a much more complicated operation, in which according to well-eſtabliſhed laws of affinity, ſpecific proportions of carbon and hydrogen unite with a certain portion of oxygen to form oxalic acid, whilſt at the ſame time other portions of the ſame baſes form different products. Hence it is inaccurate to ſtate as is ſometimes done, that *ſugar* is the baſe of the oxalic or ſaccharine acid, ſince it is a compound of hydrogen and carbon derived from the ſugar, and which the action of the nitrous acid cauſes to be ſeparated in the proportions neceſſary for that purpoſe. Hence the utmoſt action of the nitric acid on oxalic acid differs from that which it exerts on ſugar, for in the former caſe only carbonic acid and water are formed, whereas in the latter there is generated a quantity of acetous acid.

The *Malic Acid* appears to be produced along with the oxalic, in almoſt every inſtance yet examined, and it forms the greater part of the mother liquor, or fluid part from which the oxalic ſeparates by cryſtallization. The malic acid is alſo chiefly (but probably not entirely) convertible into oxalic by the further action of nitrous acid, and hence it is in ſome ſenſe an intermediate ſtate between oxalic acid and the hydro-carbonous baſe previous to oxygenation. This is ſhewn by many experiments of Scheele. This excellent chemiſt diſtilled equal parts of nitric acid and ſugar,[b] ſtopping the proceſs when the mixture in the retort had acquired a browniſh colour, which indicated that all the acid was decompoſed. The liquor was acid and of a ſyrupy conſiſtence: on adding lime-water, ſome oxalic acid ſeparated in the form of oxalat of lime. The remaining liquor was then ſaturated with lime (which occaſioned no further precipitation) after which it was coagulated by alcohol, the coagulum decompoſed by acetite of lead and ſulphuric acid (in the way deſcribed under the article *Malic Acid*) and a quantity of pure malic acid was produced. On the other hand when the proportion of nitric acid is much greater, the product of oxalic acid increaſes, and that of malic diminiſhes.

The ſame excellent chemiſt found gum-arabic treated with nitric acid, to yield a mixture of malic and oxalic acid (ſee the article *Mucilage*). Manna, the ſame; ſugar of milk the ſame, together with the ſaccholactic acid (ſee *Milk*). Salep the ſame, together with oxalat of lime; aloe, colocynth, and ſome of the reſinous gums the ſame, but in ſmaller quantity; many of the vegetable extracts the ſame, together with ſome oxalic acidulum, or ſuper-oxalat of potaſh (the potaſh being doubtleſs furniſhed from the acetite of potaſh which Vauquelin has found to exiſt in extracts). Of the eſſential oils only that of parſley could be made to furniſh theſe acids, which it did in abundance, and was totally reſolved into them.

Several animal matters were then treated with nitric acid in the ſame way. On one part of glue were poured two of nitric acid, much nitrous vapour was given out on heating, the glue was diſſolved, and the next day cryſtals of oxalic acid appeared in the liqour. The uncryſtallized reſidue ſaturated with chalk, and treated with acetite of lead and ſulphuric acid, gave the malic acid. Iſinglaſs, the white and yolk of egg, and blood, gave the ſame products. During theſe proceſſes with animal matters, as this excellent chemiſt obſerves, a quantity of thick greaſe ſeparates, little nitrous gas or carbonic acid is given out, but an abundance of *vitiated air* (azot). Another remark equally important is that whenever the oxalic acid is produced by the action of the nitric on animal or vegetable ſubſtances, a quantity of acetous acid is found in the receiver, mixed with the diſtilled nitrous acid. This latter diſcovery appears to have been made nearly at the ſame time by Scheele and Weſtrumb.

Journ. de Phyſ. tom. 28. p. 412.

Alcohol treated by nitrous acid affords a large quantity of oxalic acid, as already noticed under the article Ether *Nitrous*, hence it is always procured from the reſidue of the diſtillation of this ether. But the proportions of nitrous acid and alcohol which give the moſt oxalic acid, are different from thoſe that produce the moſt ether. The latter are about 2 of acid to 3 of alcohol, but the former ſhould be about 3 of acid to 1 of alcohol. M. Sage[c] mixed together in a retort 18 oz. of ſtrong nitrous acid with 6 of alcohol, in half an hour the mixture boiled ſpontaneouſly, and ſome ether mixed with nitrous vapour diſtilled off. The reſidue evaporated to about one ounce gave $\frac{1}{8}$ of an ounce of oxalic acid.

The production of oxalic acid from animal ſubſtances, diſcovered by Scheele, has been examined with great accuracy by Berthollet in his excellent memoirs on the nature of animal matter.[e] He ſelected ſilk for his firſt experiment on account of its apparent uniformity of compoſition. On diſtilling ſilk with ſeven or eight times its weight of nitrous acid, the whole was reſolved into a blueiſh liquor, which yielded a large quantity of oxalic acid, beſides which when the liquor was cold there was collected a thick ſcum of an oily or greaſy matter, ſimilar no doubt to that which had been obſerved by Scheele in his experiments.

M. Berthollet on ſubjecting a number of animal matters to the ſame proceſs, obtained from all oxalic acid, and this animal greaſe, but in very varying proportions. He takes no notice of the malic acid, which however muſt have been formed at the ſame time and remained in the ſolution. Of all theſe ſubſtances wool gave the greateſt quantity of oxalic acid, yielding nearly half its weight, which is more than is procured from ſugar or any known vegetable matter. Skin and hair gave nearly as much as wool. Muſcular fleſh, well waſhed, gave hardly any oxalic acid, but an unuſually large proportion of animal greaſe. This latter when in large proportion, cloſely adheres to the oxalic acid, renders it yellow, and difficult to cryſtallize. This kind of greaſe is very different from the animal or vegetable oils, and gives much ammonia by diſtillation. It appears to be derived chiefly from the azotic part of the animal ſubſtance, ſince it abounds moſt in thoſe parts that yield moſt azot, and is not produced in a ſimilar treatment of vegetable matter: whereas the baſis of the oxalic acid is unqueſtionably a mixture of carbon and hydrogen.

In no inſtance is oxalic acid produced without the ſenſible diſengagement of nitrous vapour, and the conſequent decompoſition of the nitrous acid employed. Therefore it generally requires the aſſiſtance of heat for its production. Thus M. Berthollet found that ſilk and nitric acid digeſted at the heat of 70° gave out a large quantity of azotic gas, the ſilk was diſſolved, and ſome of the animal greaſe ſeparated, but no oxalic acid was formed at that period, (ſince no precipitation was produced by lime-water), but on raiſing the temperature nitrous gas was evolved, and oxalic acid was generated.

No other agent but the nitrous acid has been yet found capable of producing the oxalic acid. Even the oxymuriatic acid, one of the moſt powerful of all the oxygenating agents, fails to convert ſugar into oxalic acid, but in its ſtead generates ſome acetous acid, and probably carbonic acid and water.

It is very commonly repreſented that there is a regular gradation of oxygenation in certain of the vegetable acids, that is to ſay, that the *ſame hydro-carbonous baſe* with a ſmall quantity of oxygen produces the tartareous acid, with a greater quantity the citric, and ſo on, and thus by merely encreaſing the doſes of oxygen it paſſes from the tartareous through the ſeveral ſtates of citric, malic, oxalic, and acetous acids, and laſtly is totally convertible into carbonic acid and water. This laſt poſition is certainly true, for as all theſe acids appear to contain only carbon, hydrogen, and oxygen in different proportions, the ultimate effect of oxygenation is to convert them into carbonic acid and water, but no unexceptionable experiment has yet been given in which any given quantity of one of theſe acids has been *totally* converted into another acid by the action of nitric acid.

In all theſe changes therefore there appears to be a new arrangement of the proportions of the hydro-carbonous baſis as well as of the oxygen, and at leaſt two, (and often more) ſubſtances are generated, however ſimple the proceſs appears to be. It is ſcarcely poſſible to aſſign a ſatisfactory reaſon for many of the changes that take place, and to explain why in ſome circumſtances the mucous acid and vinegar ſhould be formed, in others, the oxalic and malic acids, in others vinegar and carbonic acid; but from the much more frequent production of the oxalic than of any other acid, we may infer that he proportions in which its conſtituents exiſt, are thoſe in which the mutual

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[d] Mem. de l'Acad. for 1785. p. 233.

[e] Ditto for 1780 and 1785.

affinity is extremely ſtrong, and ſcarcely to be broken but by the combined effect of the moſt powerful agents. It appears probable too from Scheele's reſearches, that the malic acid is in moſt inſtances a neceſſary conſequence of the production of the oxalic, but not being cryſtallizable, nor very readily detected, it has probably been moſt commonly overlooked.

The oxalic acid is a valuable teſt in chemical experiments to determine the preſence of lime in liquids, in whatever combination this earth exiſts. The precautions required in its uſe will be mentioned under the article *Oxalat of lime*.

The affinities of oxalic acid are in the following order: lime, barytes, ſtrontian, magneſia, potaſh, ſoda, ammonia, alumine, and metallic oxyds.

OXALATS.

The oxalic acid unites with all the alkalies, earths, and moſt metallic oxyds, forming ſalts of which a very few only are of importance. This acid like the tartareous, combines with the alkalies in two different proportions, in each of which it forms cryſtallizable ſalts. One of theſe ſtates is with the acid in exceſs, forming therefore ſalts known by the general term of *acidula*, the other is when the two ingredients are in perfect ſaturation. Of theſe the *Acidulous oxalat of potaſh*, or according to Dr. Thompſon's uſeful nomenclature, the *Super-oxalat of potaſh*, has been examined with the greateſt care.

All the oxalats are readily decompoſed by heat, the acid burning off, and leaving the baſe carbonated.

OXALIC ACIDULUM. *Super-oxalat of Potaſh. Salt of Sorrel.*

A ſalt has long been prepared in ſeveral parts of Europe from the juice of the ſorrel plant, for medicinal and other purpoſes, particularly in Swabia, Thuringia, and ſome parts of Switzerland. The method of making it has been deſcribed by Savary, Cartheuſer, Weigleb, and others, and is very ſimple. Large quantities of the plant are collected and expoſed to conſiderable preſſure in a mill, (or in any other way) and the turbid juice thus expreſſed is allowed to ſtand for ſome days till much of the feculence has ſubſided. The clear liquor is then evaporated to one half, and ſet by in a cool place, and after ſome days a quantity of ſmall-grained cryſtals are depoſited. Theſe are removed, and the liquor further evaporated, by which a ſecond crop of cryſtals is collected, and ſometimes a third or a fourth is got by the ſame means. The cryſtals are at firſt very mucilaginous and impure, but by re-ſolution and evaporation they become clean, and then appear in the form of ſmall white needles, in which ſtate they are ſold at a high price for taking out iron-mould ſpots from linen, and for medicinal uſes. According to Savary, 50 lbs. of the freſh plant yield about 25 lb. of juice, from which 2½ oz. of the eſſential ſalt may be extracted. Cartheuſer[a] obtained much more, one pound of the plant giving as much as 1½ dram, which would be in the proportion of nearly 9½ oz. from 50 lbs. of the plant, but probably this was leſs pure.

The taſte of this ſalt is very ſour, ſetting the teeth on edge, but has nothing bitter or unpleaſant. The ſalt is hard and brittle, and decrepitates in the fire. It is very commonly adulterated by ſulphat of potaſh,

It was Scheele that firſt diſcovered the true compoſition of this ſalt, and ſhewed it to be compoſed of potaſh with exceſs of an acid, which by every teſt was identical with the acid of ſugar which had been lately diſcovered by Bergman. The method purſued by Scheele was the following: ſome warm water was ſaturated with ſalt of ſorrel, and a ſolution of acetite of lead was then added as long as any precipitate appeared, which laſt was edulcorated with warm water. This conſiſted of the oxalic acid united to the oxyd of lead, whilſt the ſupernatant liquor contained acetite of potaſh produced by this double decompoſition. This precipitate was then decompoſed by digeſtion with ſulphuric acid, by which the oxalat of lead was converted into an inſoluble ſulphat, and the clear liquor contained the pure oxalic acid, which was obtained in its cryſtalline form by due evaporation and cooling. The proportion of ſulphuric acid required was determined by decompoſing by this acid ſeparately as much of acetite of lead as had been uſed, and noting the quantity of acid employed. The acid thus obtained from the ſalt of ſorrel was then examined chemically, and found to agree exactly in all its properties with that obtained from ſugar by the nitric acid. A ſalt preciſely reſembling the ſalt of ſorrel was then reproduced by adding gradually to a ſolution of the acid ſome liquid carbonat of potaſh, much leſs than ſufficient for ſaturation, and during the efferveſcence occaſioned by the mixture, a number of ſmall ſaline ſpiculæ fell down, which when examined were found to be exactly the ſame with the native ſalt of ſorrel.

The oxalic acidulum may alſo be produced by adding pure oxalic acid to nitre, as the ſame eminent chemiſt alſo diſcovered, the affinity of this acid to that portion of potaſh neceſſary to form the acidulum being greater than that of the nitric acid for potaſh. In the ſame manner the oxalic acid will partially decompoſe many other of the ſalts with potaſh, ſuch as the muriat, acetite, &c. In theſe caſes the ſuper-oxalat of potaſh being much leſs ſoluble than the other ſalt, precipitates in ſmall needled cryſtals.

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[a] Murray, Appar. Med. vol. 3.

This ſalt however readily diſſolves in hot water, requiring no more than about its own weight, but the greater part ſeparates by cooling. The ſolution is not decompoſed ſpontaneouſly by long keeping,[b] in which reſpect it differs from the tartareous acidulum. The ſulphuric, nitric, and muriatic acids decompoſe this ſalt only at a boiling heat.

OXALAT OF POTASH.

When the oxalic acid is ſuper-ſaturated with potaſh and ſlowly evaporated, elegant priſmatic cryſtals are formed, in which neither the acid nor alkali predominate. This ſalt may be made by adding to the acidulous oxalat ſomewhat more potaſh than is neceſſary for ſaturation. This ſalt is much more ſoluble in water than the laſt mentioned. Alcohol diſſolves it with difficulty. It is partially decompoſed by the ſulphuric, nitric, and muriatic acids without heat, that is to ſay, a portion of the potaſh is abſtracted, and the remainder paſſes to the ſtate of the ſuper-oxalat. But with the aſſiſtance of heat it is entirely decompoſed.

OXALAT OF SODA.

The oxalic acid united to a ſmaller quantity of ſoda than will ſaturate it, forms a ſpecies of acidulum which has been but little examined. Saturated with ſoda, a ſalt is produced difficult of ſolution, and which ſeparates in ſmall cryſtalline grains.

OXALAT OF AMMONIA.

Ammonia alſo unites with oxalic acid in two proportions. When as an acidulum, it forms ſalt in ſmall cryſtals, and of difficult ſolubility, but when perfectly ſaturated the ſalt cryſtallizes in large four-ſided priſms. Theſe loſe about $\frac{1}{6}$ of their weight by a gentle heat, and are very ſoluble in water but not in alcohol. This combination of oxalic acid is the moſt uſeful for detecting the preſence of lime, as will be preſently mentioned.

Beſides theſe ſimple ſalts with the oxalic acid and alkalies, ſeveral triple ſalts (moſt of them cryſtallizable) may be formed by ſaturating the ſuper-oxalat of one alkali by a different one; thus if the ſuper-oxalat of potaſh is ſaturated with ſoda, a triple neutral ſalt is obtained, conſiſting of oxalic acid, potaſh and ſoda. In like manner ammonia readily combines with the ſuper-oxalat of potaſh and ſoda. In this as in other reſpects, the habitudes of this acid ſtrongly reſemble thoſe of the tartareous acid.

OXALAT OF BARYTES.

This acid forms with barytes a ſalt which when the acid is in exceſs, appears in the form of pellucid angular cryſtals. Boiling water diſſolves a ſmall portion, but converts the remainder into a white powder, rendered inſoluble by loſing its exceſs of acid, which the water abſtracts. On cooling, moſt of that portion which had been diſſolved ſeparates in ſmall cryſtals. This ſalt is decompoſed by ſulphuric acid.

OXALAT OF STRONTIAN.

By pouring oxalat of potaſh into muriat of ſtrontian, an inſoluble white powder is obtained, compoſed according to Vauquelin[a] of $59\frac{1}{2}$ ſtrontian, and $40\frac{1}{2}$ acid.

OXALAT OF LIME.

The oxalic acid attracts lime with greater force than any other acid, and therefore is capable of decompoſing compleatly all the known calcareous ſalts. Hence the great utility of this acid in detecting lime in every ſoluble combination. Oxalat of lime is inſoluble in water, ſo that when this acid is added to a ſolution containing lime, a white precipitate of oxalat of lime falls down, from which, when collected, waſhed, and dried in a moderate heat, the actual quantity of lime may be readily inferred. By very accurate experiments Dr. Marcet[a] found that 100 parts of oxalat of lime dried at 160° were produced from 117 of ſelenite, and the quantity of lime in the latter, alſo dried at 160°, may be reckoned to be about 41. The oxalat of lime however, though inſoluble in water, diſſolves in many of the acids without being decompoſed, and therefore when any conſiderable exceſs of acid is preſent, leſs oxalat of lime will be obtained than is really formed, and which will lead to error. On this account it is neceſſary to ſaturate any exceſs of acid before the oxalic teſt is uſed, and as an additional precaution, the oxalic acid ſhould be ſaturated with an alkali, which will not in the leaſt diminiſh its power of precipitating lime. The oxalat of ammonia is generally preferred.

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[a] Fourcroy ſyſteme.

[a] Analyſis of Brighton Water.

Oxalat of Magnesia.

This acid diſſolves magneſia, and forms a white powder which is inſoluble in water or alcohol unleſs the acid be ſuperabundant. 100 parts of the ſalt are eſtimated by Bergman to contain 35 of magneſia.

Oxalat of Alumine.

Oxalic acid digeſted on clay, diſſolves the alumine, and forms an uncryſtallizable maſs of a ſweetiſh aſtringent taſte: 100 parts contain 44 of alumine.

Metallic Oxalats.

A few only of theſe require particular notice.

Oxalat of Silver. When oxalic acid or an alkaline oxalat is added to nitrated ſilver in ſolution, a white inſoluble oxalat of ſilver is produced. Sulphat of ſilver is equally precipitated by this acid. Oxalat of ſilver is ſpeedily blackened by the ſun's rays, and in part decompoſed. In this ſtate if heated to redneſs it diſperſes with a ſudden noiſe.

Oxalat of Mercury is formed by adding this acid to any ſolution of the metal. It is a white inſoluble powder, but blackens in the ſun's rays.

Oxalat of Lead. Lead is corroded by this acid, and its oxyd is readily diſſolved, and cryſtallizes by evaporation. The oxalic acid decompoſes the nitrat and acetite of lead, but not the ſulphat, and hence in Scheele's original experiments the ſulphuric acid was uſed to diſengage the oxalic acid from the oxalat of lead formed by adding the ſalt of ſorrel to the acetite of this metal.

Oxalat of Copper. This acid diſſolves copper both metallic and oxidated. The ſalt is ſcarcely ſoluble in water. Moſt of the other ſolutions of this metal are decompoſed by the oxalic acid, and an inſoluble oxalat falls down.

Oxalat of Iron. Iron is readily diſſolved by this acid with copious diſengagement of hydrogen gas. This ſolution gives by concentration greeniſh yellow priſmatic cryſtals, eaſily ſoluble in water. It alſo diſſolves many of the ſalts and oxyds of this metal, and hence its original uſe in removing iron-mould ſpots in linen. When added to the red ſulphat or muriat of this metal, a fine red oxalat of iron is precipitated, ſoluble in an exceſs of the ſame acid.

Moſt of the other metals (gold and platina excepted) are ſoluble in this acid, forming ſalts generally of little ſolubility except with an exceſs of acid.

The ſuper-oxalat of potaſh alſo acts upon iron, copper, and ſeveral other metals, and theſe ſolutions retain the potaſh belonging to the acidulum, and cryſtallize with it into triple ſalts that deſerve further examination.

OXYD.

This term may be properly applied to any ſubſtance chemically combined with oxygen, but it is reſtricted to thoſe that have not acquired acid properties by the combination. It is chiefly uſed to expreſs thoſe modifications of metallic bodies formerly termed *calces*.

OXYGEN GAS. *Dephlogiſticated air* (of Dr. Prieſtley.) *Vital air. Empyreal air* (of Scheele.) *Der Sauerſtoffe.* Germ.

Oxygen is probably the moſt abundant of all natural bodies, and its chemical properties are ſo important that a very large ſhare of the ſcience of chemiſtry conſiſts in a knowledge of the combinations and agency of this body.

There are two immenſe ſources whence oxygen is derived, namely water and air. In the former it is condenſed into the liquid form, and combined with about a third of its weight of hydrogen: in the latter it is united with azot, and forms little more than a fifth of the atmoſphere.

There are beſides other ſmaller ſources of oxygen, ſuch as many parts of the organized world, vegetable or animal, (independent of the water which they contain ſo abundantly,) mineral acids, and metallic oxyds, &c. but the quantity from theſe latter ſources is extremely ſmall in compariſon with the former.

Oxygen when free from all combinations, (that of light and heat excepted) is in the gaſſeous form, and it was firſt obtained by Dr. Prieſtley in the year 1774 from the oxyd of mercury, and the year following it was diſcovered by Scheele, who procured it from the oxyd of mangneſe.

We ſhall not purſue the hiſtory of the diſcoveries relating to this important ſubſtance, but proceed with its properties as now fully aſcertained, and the modes of procuring it.

The pureſt poſſible oxygen gas is obtained by diſtilling *per ſe* the dry *oxymuriat of potaſh*. This ſalt is to be put into a ſmall glaſs retort, and with the heat of an Argand's lamp it melts, and then is decompoſed, giving out an abundance of oxygen gas of great purity, which is to be received over water or mercury in the uſual way. When the heat is raiſed to redneſs, all the oxygen is expelled, and in this way 100 grains of the ſalt will afford about 112 cubic inches[a] of oxygen of extreme purity. This method however is expenſive, but oxygen pure enough for moſt experiments may be got much cheaper by other ways.

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[a] Chenevix.

The black oxyd of manganeſe contains a great abundance of oxygen ſo looſely combined as to be expelled by a moderate red heat, and this is the method uſually purſued. An earthen or iron retort (the latter of which are made for this expreſs purpoſe) is to be filled with the black oxyd of manganeſe in powder, and heated in a briſk fire. The firſt product of gas comes over when the manganeſe is faintly red, and conſiſts chiefly of carbonic acid, ſo that a taper is immediately extinguiſhed. After this if ſmall ſamples of the gas are examined as it comes over by dipping a bit of kindled wood in it, the fire will ſoon be found to burn with encreaſed flame and brightneſs, a ſign of the preſence of oxygen, ſoon after which it may be collected for uſe. If the manganeſe be very good, one pound of it (which will lie in a very ſmall retort) will give about 1400 cubic inches of oxygen of great purity, that is, containing perhaps no more than a tenth of carbonic acid or any other gas. The oxygen begins to come over in quantity when the manganeſe is red-hot, and a full red heat ſhould be continued as long as any gas comes over. The reſidue is a dark grey oxyd.

Manganeſe if moiſtened with ſulphuric acid will alſo give out much oxygen on applying no greater heat than that of a taper, and hence it may be obtained very expeditiouſly with the ſimpleſt apparatus poſſible. But a great difference is found in this reſpect in the different ſpecies of manganeſe.

All the oxyds of mercury when heated red hot are decompoſed, the metal returns to the ſtate of running mercury, (which is driven up in vapour and ſoon condenſes) and the oxygen which it contained appears in the gaſſeous form, mixed with any acid, if ſuch exiſted in the oxyd. Hence the *calcined mercury* or precipitate *per ſe*, which is a ſimple combination of oxygen and mercury, when heated in a retort to a low red heat, yields only oxygen gas and mercury in vapour, the whole of the oxyd is decompoſed, the mercurial vapour condenſes into extremely pure running mercury, and the oxygen gas remains. This was the way in which Dr. Prieſtley firſt obtained this gas, and is often practiſed when a very pure oxygen gas is wanted, as it may be done in a glaſs retort ſlightly coated, held over a pan of charcoal ſo as to heat it to moderate redneſs. But as the oxyd *per ſe* is a very expenſive preparation, the red nitrous oxyd is uſually ſubſtituted. (See the articles *Mercury* and *Atmoſpherical Air.*) Theſe oxyds yield about $\frac{1}{7}$ of their weight of oxygen gas. This gas is however at firſt a little impregnated with mercurial vapour, which is depoſited as a white film on the ſurface of the water over which the gas ſhould ſtand for a day.

Turbith mineral (the ſulphated oxyd of mercury) yields much oxygen in this way, mixed with ſome ſulphureous acid.

The *Red oxyd of Lead* or *Minium* heated to redneſs in an earthen retort gives abundance of oxygen, but mixed with ſome carbonic acid gas.

All the oxyds of iron when heated to full redneſs begin to give out oxygen in conſiderable purity.

Oxygen gas may alſo be obtained very cheap and conſiderably pure, by the deſtructive diſtillation of nitre in a moderate red heat. This proceſs which highly illuſtrates the decompoſition of nitric acid, has been already noticed under the article *Nitrat of Potaſh*. To obtain oxygen from it, put ſome dry nitre in a coated glaſs or an earthen retort, lute a tube to it to convey away the gas to the proper veſſels, filled with and inverted over water, and apply a heat gradually raiſed to redneſs. When red-hot, the acid of the nitre is decompoſed, and a very large quantity of oxygen is given out for a conſiderable time, till at laſt all the acid is diſſipated in the form of oxygen and azot, and cauſtic potaſh remains in the retort, which laſt if the operation be puſhed to the utmoſt, corrodes the retort and renders it unfit for a ſecond charge. The oxygen is conſiderably pure in this way, but is mixed with a portion of azot, particularly towards the laſt. It is obtained ſimpler and cheaper by ſubſtituting to the retort two earthen crucibles, one inverted over the other, and the point of contact between the two well luted, and a tube proceeding from the upper crucible to convey away the gas.[b] Nitrat of ſoda will anſwer as well, as will moſt of the metallic nitrats, and many other ſubſtances moiſtened with nitric acid. Dr. Prieſtley obtained from 2 oz. of nitre heated in an earthen retort, about 812 oz. meaſures, and the veſſel melted with the alkali before the proceſs was finiſhed.

All the nitrats (nitrated ammonia excepted) will yield oxygen gas when expoſed to a heat ſufficient to decompoſe the acid.

Moſt of the green parts of vegetables while living, yield oxygen gas when expoſed to the ſun's rays. Of theſe the green conferva of ponds is a remarkable inſtance, as Dr. Ingenhouſz has ſhewn by experiment.

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[b] An. Chim. Tom. 15. p. 187.

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The ſpecific gravity of oxygen gas according to Kirwan is 0.00135, or 740 times lighter than water, (at 30 inches bar. and 60° therm). and it is heavier than common air in the proportion of 1103 to 1000. The weight one hundred cubic inches of it is equal to 34 grains; but Mr. Davy makes it 35.06. The expanſion or contraction which it undergoes by changes in preſſure and temperature, will be given in the appendix.

This gas is only in a very ſmall degree abſorbed by water. According to Mr. Henry's experiments, 100 cubic inches of well boiled water abſorb 3.55 of oxygen. This ſolution has no particular ſenſible qualities.

The characters that peculiarly diſtinguiſh oxygen gas, are the eminent degree in which it ſupports combuſtion and reſpiration; and it is proved that neither of theſe can go on without oxygen, and that it is ſolely owing to its preſence that atmoſpheric air and the other compound gaſſes are fitted for maintaining theſe grand proceſſes of the material world. The function of reſpiration will not be treated of in this work, it may therefore be merely mentioned in this place, that if a ſmall animal is immerſed in oxygen gas, it will live much longer than in the ſame quantity of common air, and if the carbonic generated in the proceſs be occaſionally removed by alkalies, the animal will remain in the gas uninjured for a much greater length of time. In this and in many other reſpects the proceſſes of reſpiration and combuſtion agree, but ſtill there are ſome circumſtances which render it probable that the diluter ſtate of oxygen, (ſuch as it exiſts in common air) is altogether *fitter* for animal reſpiration than a purer oxygen.

The burning of the ſeveral combuſtible bodies in oxygen gas, forms a number of moſt beautiful and inſtructive experiments, and has contributed more than any thing elſe to give accurate ideas on the nature of combuſtion in general. Some of the experiments are the following:

Immerſe a lighted taper in the gas, and it will burn with a prodigious encreaſe of rapidity, and a dazzling light.

Heat the top of a bit of charcoal red-hot, (which if merely left in the open air will ſoon be covered with a white aſh, and be extinguiſhed); introduce it into oxygen gas, and the kindled part will ſuddenly glow with a bright heat, and emiſſion of brilliant ſparks for a certain time, after which it will go out. The bulk of the remaining gas is not much altered, but a large quantity of the oxygen will be conſumed, and in its ſtead much *carbonic acid gas* will be generated, which will inſtantly render lime water milky when ſhaken with it, and may be removed by lime or alkalies. The weight of carbonic acid will be found to equal the loſs ſuſtained by the charcoal and by the oxygen united.

Introduce a ſmall piece of phoſphorus into a large jar of oxygen, with an atom of lighted tinder in contact with it. (The beſt apparatus for theſe experiments will be mentioned in the appendix.) The phoſphorus will burn with a vaſt body of bright light, ſo brilliant that the eye can hardly ſupport it, and with intenſe heat and rapid emiſſion of white fumes. The heat at firſt expands the gas, and if the jar is quite full throws part of it out, but preſently there is a rapid abſorption, the water being ſucked up into the jar, and if the gas were quite pure none would be left. The white vapours are *phoſphoric acid*, the product of the combuſtion, and obviouſly compounded of phoſphorus and oxygen, as in the former experiment the carbonic acid gas was produced by the union of charcoal and oxygen.

Provide a bottle with a cork perforated to admit a glaſs tube drawn out to a tolerably fine point, and bent at right angles in the middle. Fill the bottle nearly full with very dilute ſulphuric or muriatic acid, and throw in ſeveral ſmall bits of zinc. This will produce a copious ſtream of hydrogen gas, which (when it has run to waſte for a ſhort time to expel the common air of the bottle) kindle at the end of the glaſs tube, and immediately introduce it into the ſide opening of a ſmall tubulated receiver, full of oxygen, through the perforation of a cork cut to fit exactly, whilſt the neck of the receiver is inverted over water. The ſtream of hydrogen will burn with an enlarged flame, and without any ſmoke, and all the inſide of the receiver will be covered with a watery dew. The gas will gradually diſappear and the water riſe. In this proceſs (and others more accurate will be mentioned under the article *Water*) the ſole product is water, which therefore is produced by the union of hydrogen and oxygen at a high temperature.

Make a ſpiral coil of iron wire, and kindle it, and introduce it into oxygen gas. (The manner of performing the experiment is deſcribed under the article *Iron*, and in the Appendix). After a moſt brilliant combuſtion the iron will be melted in drops at the bottom of the veſſel, and converted into an *Oxyd of Iron*.

The above are only a few of a number of beautiful experiments which have been deviſed, to ſhew the rapidity with which bodies burn in oxygen gas, and the products of ſuch combuſtion.

The proceſs of combuſtion, which is one of the moſt ſtriking and moſt familiar of all the natural phenomena, has long engaged the utmoſt attention of philoſophers. It is not our intention, in a work like the preſent, which chiefly aims at collecting and recording facts and familiar proceſſes, to give any hiſtory of the theories that have been advanced on this curious and difficult ſubject. It will be ſufficient to obſerve that there have been at leaſt three hypotheſes made to account for combuſtion, together with ſeveral modifications of each. The firſt in order of time is the *Phlogiſtic* theory, which was brought to a very ingenious ſyſtem by Stahl, who is generally looked upon as its author. This able philoſopher ſuppoſes that all inflammable bodies (or ſuch as *burn* with emiſſion of light and heat) contain a portion of an intangible, imponderable principle, called phlogiſton, to which they owe their inflammability with all its attendant phenomena. Whilſt a body is burning, it parts with its phlogiſton, which paſſes into combination with the ambient air, and it is thus reduced for the moſt part into an aſh, or (if a metal) into a calx, which differs from the original ſubſtance only in being deprived of phlogiſton. Therefore (to take a metal as an example) in order to reduce the *calx* to the metallic ſtate, it is neceſſary to unite it with ſome inflammable ſubſtance, ſuch as charcoal, which reſtores its phlogiſton, and brings it back to the metallic or reguline ſtate.

But this ingenious hypotheſis was made before the diſcovery of oxygen, and before the preciſe agency of air in maintaining combuſtion was underſtood, and therefore the ſeveral modifications made to accommodate it to all the then known chemical facts, were all eſſentially defective.

The diſcovery of oxygen by Dr. Prieſtley, followed at no great length of time, which gave riſe to the moſt admirable and beautiful reſearches of Lavoiſier, on the ſubject of combuſtion, in which this excellent philoſopher demonſtrated that in all caſes of combuſtion, the inflammable ſubſtance united with oxygen, and produced either an acid, or an oxyd, or water, or a mixture of theſe three, and the weight of the product above that of the ſimple combuſtible was exactly equal to the quantity of oxygen which had diſappeared. In this reſpect therefore the ſyſtem ſo finely brought out by Lavoiſier was not ſo much an improvement of Stahl's, as an eſſential addition to it and all other previous theories, by accounting for the increaſe of weight of the *product* of combuſtion over that of the combuſtible. But *combuſtion* implies the diſengagement of light and heat, which was ſtill to be explained, and this was done by Lavoiſier, to the utter excluſion of phlogiſton (the exiſtence of which was at all times very problematical) by ſuppoſing oxygen gas to be a compound of oxygen with heat and light, and therefore whilſt a body *burns* (according to Lavoiſier) it abſorbs oxygen from the air, ſeparating it from the heat and light with which it was united, and which then appear in the ſenſible form of *fire*. This ſyſtem therefore allows of no other difference between combuſtion and ſlow oxygenation, than that in the former caſe, the proceſs going rapidly, the heat and light ſeparated from the oxygen gas appear in the form of viſible flame, and in the latter they eſcape ſlowly and imperceptibly to the ſenſes.

From the way in which Lavoiſier expreſſes himſelf however, it might be ſuppoſed, that he conceived that the only portion of caloric which could be ſet free during combuſtion, was that which is eſſential to the gaſeous form, or that which makes the ſole difference between a ſolid body and the ſame body gaſſified, analogous to the difference in this reſpect between ſteam and fluid water. Hence it would follow that no oxygen in ſolid or liquid combination could maintain combuſtion, a poſition which is inſtantly refuted by the well-known power of the ſolid oxygen of nitre and oxymuriat of potaſh to inflame charcoal, or the liquid oxygen of nitric acid to kindle eſſential oils.

If therefore oxygen is the ſource of the heat diſengaged during combuſtion (which is extremely probable) it muſt be allowed in ſeveral inſtances to carry the greater part of its heat with it into various combinations, ſo that the oxygen of nitric acid which can ſupport combuſtion, muſt be allowed to be different from that of water (for example) which cannot: and nitric acid therefore muſt be called a compound of azot, and *oxygen with its caloric*; and water a compound of hydrogen and *oxygen without its caloric*. This diſtinction has been well pointed out by Brugnatelli, [a] who terms the former ſtate *thermoxygen*, and the latter ſimply *oxygen*.

It is a preſumptive argument too, that the heat given out during combuſtion is chiefly derived from the oxygen, that the increaſe of temperature is generally pretty accurately proportioned to the quantity of oxygen conſumed, as was found by Meſſrs. Lavoiſier and La Place, in their experiments with the *calorimeter*.

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[a] Journ. de Phyſ. tom. 53.

Several objections of weight however oppoſe the hypotheſis that *light* is alſo a conſtituent part of oxygen gas, or of oxygen in any ſtate fit to ſupport combuſtion. One of the ſtrongeſt is, that the quantity of light given out in this proceſs, is *not* proportioned to the quantity of heat, and the circumſtance of the various colour which the flame aſſumes, according to the nature of the combuſtible body, would ſeem rather to indicate that it is this latter, and not the oxygen gas, which is the principal ſource of the light.

This opinion has been adopted by ſeveral chemiſts of late years, among whom are Gren and Brugnatelli, and Dr. Thomſon. So that according to this ſyſtem the proceſs of combuſtion is in fact a double decompoſition, in which the combuſtible body unites with oxygen to form an oxyd, or water, or an acid, according to circumſtances, whilſt the light of the combuſtible combines with the caloric of the oxygen, and produces the flame or fire

It will be eaſily ſeen that this ſyſtem in one part bears a reſemblance to the ancient hypotheſis of phlogiſton, inſomuch that both of them ſuppoſe a ſomething to be contributed by the combuſtible body itſelf towards the compoſition of the *fire or flame*, and this too appears on the whole more conſonant with the general phenomena of combuſtion and oxygenation; but ſtill there remain a vaſt number of difficulties to be cleared up before it can be fully admitted.

The lateſt, the moſt laboured, and certainly one of the moſt ingenious theories of combuſtion, is that of Dr. Thompſon, who adopts the above-mentioned modification of the phlogiſtic ſyſtem, and has given a very ſatisfactory view of the actual phenomena as far as they are known, to which we ſhall refer the reader.[b]

OXYMURIATIC ACID.[a] *Acide muriatique oxygéné*. Fr. *Oxygeniſirte Salzsäure*. Germ. *Dephlogiſticated Marine Acid* of Scheele.

This acid was firſt diſcovered by Scheele in conſequence of digeſting the black oxyd of manganeſe with muriatic acid. It is beſt prepared in the following way. Charge a long-necked tubulated glaſs retort not more than one-fourth full of 8 parts, by weight, of muriated ſoda, and 3 parts of black oxyd of manganeſe, theſe ingredients being in fine powder, and accurately mixed together; then add 5 parts of ſulphuric acid, diluted with 4 parts of water: the beak of the retort being now introduced into a common water bath filled with warm water, and a gentle heat being communicated to the ingredients by means of a lamp, a ſpeedy effervescence will take place, the common air will be driven out of the retort by a light yellow coloured gas, which is oxymuriatic acid, and may be collected in inverted vials in the uſual manner. The *rationale* of the proceſs is this: ſulphuric acid when heated with black oxyd of manganeſe, drives off part of its oxygen, and then forms with the remaining ſub-oxyd ſulphat of manganeſe: muriat of ſoda is alſo decompoſed by ſulphuric acid, the muriatic acid being ſeparated by the ſuperior affinity of the ſulphuric. But if theſe two diſtinct decompoſitions take place at the ſame time and in the ſame veſſel, the oxygen and muriatic acid gaſſes while in a naſcent ſtate, combine together producing a new compound, oxymuriatic gas, which being but little ſoluble in warm water, is collected as we have juſt deſcribed; any portion of common muriatic acid that might be accidentally mixed with it being compleatly ſeparated by means of the water through which it paſſes. This gas may alſo be procured in a more ſimple, though not quite ſo eligible a manner, by digeſting ſtrong muriatic acid with about half its weight of black oxyd of manganeſe.

Oxymuriatic acid gas is of a light yellowiſh green colour: its ſpecific gravity has not been aſcertained. Its odour is more penetrating and ſuffocating than even that of ſulphureous acid, occaſioning a long-continued and convulſive cough, even when largely mixed with common air; when pure, or nearly ſo, it is inſtantaneouſly fatal to animal life. A cubic inch of water at 43° Fahr. is capable of abſorbing 1.07 grains troy of this gas, and thereby acquires a denſity of 1.003: but though cold water takes up this gas without much difficulty, it is nearly inſoluble in hot water: hence the beſt method of obtaining the liquid acid is by means of a Woulfe's apparatus, the bottles of which are ſurrounded with ice; by this management, when the water is nearly ſaturated with the gas, it depoſits thin lamellar cryſtals of oxymuriatic acid, which again diſſolve and mix with the reſt of the fluid on a ſmall increaſe of temperature; and at a higher heat, part of the acid eſcapes in an elaſtic form.

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[b] Syſtem of Chemiſtry and Phil. Journ. 8vo. Vol. 2.

[a] Berthollet, Chem. ſtatique. II.

Both in colour and odour the liquid acid is ſimilar to, but weaker than the gas, to the taſte it is auſtere and ſomewhat acrid, but not ſour. It differs from other acids in entirely diſcharging all vegetable colours except charcoal black, nor are they capable of being reſtored by the ſubſequent application of an alkali. The ſame effects are produced by the gaſſeous acid, but if this in a concentrated ſtate is allowed to remain long in contact with vegetable fibre, it weakens its texture, and turns it firſt to yellow and at length brown, by carrying off the hydrogen and reducing the carbon nearly to the ſtate of charcoal. The colour is in like manner diſcharged from animal fibre, but the deſtructive action of the acid on the fibre taking place at the ſame time, a yellow colour is evolved, which no after proceſs can get rid of. Thus if a mixed ſtuff of linen and woollen be dyed with indigo, and afterwards ſubmitted to the action of either the gaſſeous or liquid acid, the blue colour will be found in the courſe of an hour or two to be deſtroyed, and the fibres of the linen will appear white, and thoſe of the wool yellow.

Oxymuriatic acid gas, though fatal to animal life, is in many caſes capable of ſupporting combuſtion: a lighted taper if plunged ſuddenly in it, is often extinguiſhed, but if let down gently it continues to burn with a remarkably red, but ſomewhat diminiſhed flame, and a very copious ſmoke, being at the ſame time conſumed with uncommon rapidity. Light appears to have no effect on this gas, and it may be paſſed through a red hot earthen or glaſs tube without any change, except a temporary increaſe in bulk. The liquid acid on the contrary, undergoes a decompoſition by the action of light, oxygen gas being evolved, and the acid returning, for the moſt part at leaſt, to the ſtate of common muriatic: whence the neceſſity of keeping it in an opake bottle, or in a dark cloſet.

Oxymuriatic acid gas, when mixed with hydrogen and paſſed through a red hot earthen tube, is rapidly decompoſed, inflammation and detonation being the conſequence, a ſimilar effect takes place if a lighted match is applied to the mixed gaſſes; but at the uſual temperature the mutual action of theſe two gaſſes is very ſlow; at length however the oxygen of the acid gas combines with the hydrogen, and liquid muriatic acid is the reſult.

Sulphur at the common temperature ſlowly decompoſes oxymuriatic acid gas, and is itſelf partly acidified; but if melted ſulphur is introduced into a jar full of the gas, an immediate inflammation takes place, and ſulphuric acid is formed. The liquid acid has no action on ſulphur.

Sulphuretted hydrogen and oxymuriatic acid gas mutually decompoſe each other, but without inflammation; if the latter is leſs in quantity than the former the hydrogen only of the ſulphuret is oxygenated, but if the acid is conſiderably in exceſs, both the hydrogen and ſulphur are oxygenated, and the products are muriatic and ſulphuric acids and water. An analogous effect takes place if the acid and hydro-ſulphuret are employed liquid inſtead of gaſſeous. When the acid is poured by ſucceſſive ſmall portions into the hydro-ſulphuret, this latter is decompoſed, and its ſulphur is precipitated: but if this is reverſed, and the hydro-ſulphuret is poured into the acid, no precipitation takes place, the ſulphur being acidified.

Phoſphorus, if cut into ſmall pieces and dried in blotting paper, deflagrates with a bright flame as ſoon as it is introduced into oxymuriatic acid gas, the oxygen being at the ſame time transferred from the acid to the phoſphorus. This combuſtible body has no action on the liquid acid, except it is aſſiſted by a ſtrong light: in this caſe the oxygen, as it quits the oxymuriatic acid, unites ſlowly and ſilently with the phoſphorus, which is thus acidified.

Phoſphuretted hydrogen readily decompoſes the gaſſeous acid, a flame (not however ſo bright as when oxygen gas is employed) making its appearance at the inſtant of their union. If the acid and phoſphuret are mixed together in a liquid ſtate, the decompoſition happens with preciſely the ſame modifications as we have juſt deſcribed with regard to liquid hydroſulphuret. Phoſphorized eſſential oil, by remaining a few minutes in this acid gas, becomes conſiderably heated, but does not inflame, if however in this ſtate it be removed into the common air, it takes fire with a kind of exploſion.[b]

All the metals decompoſe oxymuriatic acid gas, and many of them, if ſufficiently attenuated, undergo actual inflammation. Thus if a leaf of gold or copper be let down into a wide-mouthed vial full of this gas, the metal will burn with a green light, will be oxydated, and will then combine with the muriatic acid with which it finds itſelf in contact. Several of the metals, ſuch as antimony, arſenic, biſmuth, and tin, when reduced to a fine powder and poured into the gas, become immediately red hot, and preſent the appearance of a ſhower of fire. Some of the metallic ſulphurets, eſpecially thoſe of mercury, antimony, and arſenic, in like manner decompoſe this gas, being themſelves ignited and oxygenated.

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[b] Pickel, in Ann. de Chem. xiii. p. 223.

The liquid oxymuriatic acid is decompoſed by all the metals, and the reſulting ſalt is a muriat, the baſe of which is at a high degree of oxydation. None of the metals during their ſolution in this acid give out hydrogen, as they do when acted on by ſimple muriatic acid, for the oxygen which in this latter caſe they obtain from the decompoſition of part of the water, is procured in the former caſe by the decompoſition of the acid.

From the very ſmall difference between the ſpecific gravities of water and liquid oxymuriatic acid, it is obvious that the proper acid part of the fluid is in a ſtate of but little condenſation, hence it appears that in this form it is incapable of diſlodging the carbonic acid from carbonat of lime, and probably from any other of the perfectly neutralized alkaline carbonats, except perhaps carbonat of ammonia. If therefore ſome finely pulverized calcareous ſpar be digeſted in liquid oxymuriatic acid, it will be found to diſſolve in this fluid without the diſengagement of a ſingle bubble of carbonic acid: in proportion as it becomes charged with this earthy carbonat, its yellow colour diſappears, and its peculiar odour becomes leſs and leſs perceptible. On the addition of lime-water or a ſolution of cauſtic potaſh, the carbonat of lime is precipitated unaltered.

The action of ammonia upon oxymuriatic acid gas is very remarkable. If a ſtrong glaſs jar filled with 18 or 20 cubic inches of the latter ſubſtance, be placed in a mercurial bath, and two or three cubic inches of ammoniacal gas are thrown up into the jar, a pretty conſiderable detonation accompanied by a white light and abſorption takes place, and a thick vapour is produced; in a ſhort time the vapour condenſes into a fluid conſiſting of water, muriatic acid, and a little ammonia, and the gas remaining in the jar will be found to be nearly pure azot. Hence it is manifeſt what happens during this proceſs: the greater part of the ammonia is decompoſed into its elements azot and hydrogen, of which the former aſſumes the elaſtic ſtate, while the latter reacts on the oxymuriatic acid, deprives it of its oxygen with which it combines to form water, which, as ſoon as produced, unites with the muriatic acid and undecompoſed ammonia, thus compoſing a watery ſolution of acidulous ammoniacal muriat.

The preciſe mode in which the fixed alkalies act on oxymuriatic acid is a ſubject on which chemiſts are not yet perfectly agreed. Thoſe who have paid the moſt attention to this intricate ſubject are Berthollet and Chenevix, from whoſe experiments we ſhall ſelect the following particulars, beginning with thoſe of the laſt mentioned chemiſt.

The bottles of a Woulfe's apparatus were charged, the firſt with a ſolution of pure potaſh in ſix parts of water, the ſecond with a ſolution of pure potaſh in about twenty parts of water, and the third with a ſolution of common carbonat of potaſh: the third bottle was connected with a pneumatic apparatus, and the firſt with a retort charged with muriat of ſoda, ſulphuric acid, and black oxyd of manganeſe, in the uſual proportions. By a gentle heat oxymuriatic acid gas was liberated in abundance, and paſſed into the firſt bottle, where it was abſorbed by the alkali; when this was ſaturated the acid gas began to combine with the potaſh of the ſecond bottle, any muriatic or ſulphuric acid that might caſually riſe from the retort along with it, being detained by the alkali of the firſt. By this management nothing but pure oxymuriatic acid was brought into contact with the potaſh in the ſecond bottle, and the proceſs was continued till the liquor ſhowed an exceſs of acid. A portion of this liquor was diſtilled to dryneſs in a glaſs retort, care being taken to prevent the acceſs of light: during this proceſs nothing came over except water and a little of the dilated air of the veſſels, it is manifeſt therefore that the dry ſalt thus obtained held all the oxygen that had been contained in the oxymuriatic acid, which had combined with the potaſh in the ſecond bottle of the Woulfe's apparatus. 100 grains of this dry ſalt were then diſſolved in water, and by the addition of nitrat of ſilver a quantity of muriated ſilver was precipitated, indicative of 84 parts of muriated potaſh: but in this ſalt the acid is not oxygenated, hence it follows that the remaining 16 parts not decompoſable by nitrated ſilver, were *hyper-oxymuriat of potaſh*, the acid of which was combined with all the oxygen formerly united with that of the 84 parts of muriated potaſh, and therefore at a much higher degree of oxygenation than common oxymuriatic acid. Hence it appears that the effect of liquid potaſh on oxymuriatic acid is to decompoſe it by transferring the whole of its oxygen to a

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[c] Chenevix in Phil. Trans. 1802. p. 131.

ſmall part of the acid, and thus reducing the remainder to the ſtate of common muriatic. That this change is entirely compleated almoſt immediately upon the alkali and oxymuriatic acid coming in contact with each other, is proved according to Mr. Chenevix by the following experiment. He decompoſed by nitrat of ſilver 400 grains of the liquor prepared in the ſecond Woulfe bottle, and obtained 71 grains of muriated ſilver. A like quantity of the liquor was then gradually evaporated to dryneſs, and the reſidual ſalt again diſſolved in water; from this, nitrat of ſilver threw down 70 grs. of muriat. Now if in the former caſe any of the acid had been in the ſtate of oxymuriatic, the amount of hyper-oxymuriatic and muriatic acids would have been proportionably diminiſhed, and alſo of courſe the precipitate of muriated ſilver. Thus as appears from the experiments and reaſoning of Mr. Chenevix, when cauſtic potaſh is ſaturated by oxymuriatic acid gas, an immediate decompoſition of this laſt takes place, no oxymuriat of potaſh is formed, but ſimple muriat and hyper-oxymuriat in the proportion of 84 of the former to 16 of the latter.

But ſome doubts as to the legitimacy of the concluſions deduced by Mr. C. from his experiments have been ſuggeſted by M. Berthollet, which we ſhall now proceed to ſtate. And firſt as to the proof by nitrated ſilver: this according to the able chemiſt juſt mentioned, is not in this caſe to be depended on, ſince the affinity of the oxyd of ſilver for muriatic acid may itſelf determine the transfer of oxygen neceſſary to the production of hyper-oxymuriatic acid. As a further proof that the decompoſition of the oxymuriatic acid into common muriatic and hyper-oxymuriatic acids is a much more gradual proceſs than it is ſuppoſed to be by Mr. Chenevix, the following experiment was made by M. Berthollet.[d] Into a ſolution of potaſh a quantity of oxymuriatic acid gas was paſſed, not quite ſufficient to ſaturate the alkali: the reſulting fluid was divided into two equal portions, of which one was immediately expoſed to the action of light, and the other was kept in the dark for a fortnight, and then ſet in the ſunſhine. Now it is the effect of light to decompoſe the oxymuriatic acid, but not the hyper-oxymuriatic, by liberating its oxygen, hence if the decompoſition of the former had been immediate and total on its experiencing the action of the alkali, no oxygen gas ought to have been produced, but in fact the former portion of liquor afforded 16 parts, and the latter portion 7 parts of this gas, whence it follows, firſt, that the decompoſition of the oxymuriatic acid by means of potaſh is only partial, and ſecondly that it is not inſtantaneous. A further proof of the correctneſs of this repreſentation is that the liquor in queſtion retained the property of diſcharging vegetable colours, which is characteriſtic of the oxymuriatic, but not of the hyper-oxymuriatic acid. A remark by Mr. Hoyle[e] may be brought in further confirmation of M. Berthollet's theory, namely, that after ſeparating the hyper-oxymuriat of potaſh from the liquor in the form of cryſtalline plates and needles by refrigeration, there was obtained by evaporation a muriat of potaſh, conſiderably oxygenated, though not capable of detonating with ſulphur, and therefore not in the ſtate of hyper-oxymuriat.

Some further experiments of M. Berthollet have alſo confirmed a former obſervation made by him, and afterwards called in queſtion by Mr. Chenevix, which is, that if oxymuriatic acid gas be paſſed into a ſomewhat concentrated ſolution of potaſh, the affinity of this laſt for muriatic acid becomes ſo powerful as to decompoſe it at a greater rate than hyper-oxymuriat of potaſh can be formed, in conſequence of which an actual diſengagement of oxygen gas takes place, and as the experiment ſucceeds perfectly well in the dark, it is obvious that the action of light has nothing to do in this caſe.

The proportions of the ingredients of oxymuriatic acid were firſt ſtated by Berthollet at

89 Muriatic acid
11 Oxygen

100

The mode by which he obtained this reſult, though very ſimple, was not however quite correct. He ſaturated with the acid gas 50 cubic inches of water and expoſed it to the ſun till it ceaſed to give out oxygen gas: the quantity of this latter thus procured, amounted to 8 grs. and the reſidual liquor by the teſt of nitrated ſilver indicated 65 grs. of muriatic acid. Hence : 73 : 8 :: 100 : 11 nearly. But M. Berthollet himſelf is of opinion that the whole of the oxygen was not ſeparated from the liquor by the action of light, and has acquieſced in the proportions laid down by Mr. Chenevix according to the following method of analyſis. Having ſlightly ſuperſaturated a ſolution of potaſh by paſſing oxymuriatic acid gas into it, he evaporated the liquor to dryneſs and then rediſſolved 100 parts of the ſalt in water; then by the teſt of nitrat of ſilver he aſcertained the preſence of 84 parts of muriated potaſh, (conſiſting of 27.88 muriatic acid and 56.12 potaſh) and 16 parts of hyper-oxymuriat of potaſh (conſiſting of 9 parts oxygen, 3.2 muriatic acid, and 3.8 potaſh). Hence $(27.88+3.2)=31.2$ muriatic acid $+9$ oxygen $=40.2$ oxymuriatic acid: therefore this acid is compoſed of

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[d] Chim. Stat. §. 317.

[e] Manchester Phil. Tranſ. V. p. 226.

84	muriatic acid
16	Oxygen
100	

Although there ſeems little reaſon to doubt the exiſtence of the claſs of proper oxymuriats, yet they have not as yet been the ſubject of chemical inveſtigation.

HYPEROXYMURIATIC ACID.

This acid exiſts in the alkaline, earthy and metallic hyper-oxymuriats, but cannot be diſengaged except in a ſtate of greater or leſs decompoſition by any means that have hitherto been attempted. On account of the large proportion of oxygen which it contains, the effects produced by it on combuſtible ſubſtances are much more rapid and violent than thoſe occaſioned by oxymuriatic acid. It is compoſed according to Mr. Chenevix, whoſe experiments on this ſubject will be mentioned in the next article, of

35	Muriatic acid
65	Oxygen
100	

The order of its affinities as aſcertained by Mr. Chenevix is, potaſh, ſoda, barytes, ſtrontian, lime, ammonia, magneſia, alumine.

Hyperoxymuriat of Potash. Common oxymuriat of potaſh.

This ſalt is beſt prepared by charging one or two Woulfe bottles with a moderately ſtrong ſolution of ſemi cauſtic potaſh (purified pearlaſh) and then throwing in oxymuriatic acid gas from a mixture of common ſalt, black oxyd of mangane ſe and ſulphuric acid: when the alkali is nearly ſaturated, an efferveſcence for the moſt part of carbonic acid, makes its appearance, and thin ſaline ſcales begin to be precipitated: after the efferveſcence has ceaſed, the contents of the bottles may be poured into a wide mouthed flaſk and ſet for a few hours in a dark cold place; a conſiderable quantity of cryſtalline plates will be thus depoſited, which are hyperoxymuriat of potaſh. Theſe being taken out of the liquor and drained are to be rediſſolved in hot water, which by cooling will depoſit the greater part of the ſalt, and generally a little earthy matter, which is oxyd of manganeſe; and this is finally to be got rid of by re-ſolution and cryſtallization.

The ſalt thus obtained is in the form of thin glittering ſcales, of a pure ſilvery white colour not unlike boracic acid, but if the mother water of the laſt cryſtallization is expoſed to ſpontaneous evaporation, its ſalt will be depoſited in ſhort obtuſe rhomboidal priſms.

It is inodorous. To the taſte it is cooling and ſomewhat pungent and auſtere: it has been compared in this reſpect to nitre, from which however it is very ſenſibly different. Its ſp. gr. is 1.98. It crackles and emits ſparks of light when rubbed briſkly in a mortar. It is ſoluble in 16 or 17 parts of water at 60°, and in two and a half parts of boiling water; alcohol is alſo capable of taking up a ſmall portion. Neither the dry ſalt nor its aqueous ſolution are in the leaſt affected by expoſure to the light. When expoſed to the air it becomes ſomewhat damp in moiſt weather, and at length acquires a ſlightly yellow tinge.

When heated by a lamp this ſalt decrepitates gently, and then melts and loſes about two *per cent.* being chiefly water of cryſtallization; if heated to redneſs it is rapidly decompoſed, a torrent of pure oxygen gas being given out, and the ſalt is converted into muriat of potaſh: from 100 parts thus treated, and further decompoſed by nitrat of ſilver, Mr. Chenevix obtained

20	Muriatic acid
38.3	Oxygen
39.2	Potaſh
2.5	Water
100.0	

The action of ſulphuric acid upon hyperoxymuriat of potaſh is very remarkable: if ſome of the concentrated acid be poured upon this ſalt a violent decrepitation, ſometimes accompanied by a flaſh, takes place, and a thick heavy vapour of a greeniſh yellow colour is diſengaged. The ſmell of this vapour reſembles that of a mixture of nitrous gas with that emitted from burning brick-kilns, hence it is very different from the odour of oxymuriatic acid, neither is it by any means ſo ſuffocating and oppreſſive to the lungs. Beneath this vapour is a bright orange coloured liquor which has the ſame odour as the vapour. This liquor is a mixture of ſulphuric acid, potaſh, and hyperoxymuriatic acid, not indeed ſo pure as when combined with the potaſh but mingled more or leſs with muriatic and oxymuriatic acids. If this mixture of hyper oxymuriat of potaſh and ſulphuric acid be heated over a lamp or in any other way, by the time that it has acquired the temperature of 125° or thereabouts, an exceedingly loud exploſion accompanied by a white and vivid flaſh takes place, breaking the veſſel in which the mixture is contained, and diſperſing its fragments with great violence in every direction. If the ſulphuric acid inſtead of being concentrated is diluted with twice or thrice its weight of water, and the beak of the retort containing the materials is dipped in a baſon of water with an inverted jar of the ſame placed over it, there will happen a rapid diſengagement of a yellowiſh gas without riſk of exploſion on the application of a lighted lamp. This gas when it enters the water of the jar will be in part abſorbed, forming a weak liquid oxymuriatic acid mixed with common muriatic acid, and the unabſorbed portion will be found to be oxygen gas. Hence it is evident that hyperoxymuriatic acid cannot be ſeparated from its combination with potaſh by either ſtrong or weak ſulphuric acid, without at the ſame time undergoing decompoſition.

Nitric acid produces nearly the ſame phenomena with this ſalt, but in a leſs marked and diſtinct manner.

Muriatic acid decompoſes this ſalt, but neither the yellow vapour nor the orange-coloured liquor are produced: by the application of a gentle heat an acid gas is liberated which, although not hyperoxymuriatic acid, is conſiderably more oxygenated than oxymuriatic acid: the compoſition of this gas is however by no means uniform, depending very materially on the quantity of muriatic acid employed beyond what is abſolutely neceſſary to the ſaturation of the alkali. The oxymuriatic gas made uſe of by Mr. Cruickſhank, in his analyſis of the hydrocarbonats, was thus procured, and conſiſted of 56.5 muriatic acid, and 43.5 oxygen.

Oxalic, tartareous, and citric acids, are alſo capable of decompoſing this ſalt, but the acid gas that is liberated is leſs oxygenated than when any of the three mineral acids is made uſe of. Phoſphoric and arſenic acids exert no action on this ſalt except by the aſſiſtance of heat, in which caſe much oxygen gas is evolved, and conſequently the acid is leſs oxygenated.

The acid diſengaged from hyperoxymuriat of potaſh by ſulphuric or nitric acids, affects combuſtible ſubſtances in the ſame manner as common oxymuriatic acid gas does, only with more violence and rapidity, on account of its containing a much larger proportion of oxygen. Thus if a grain of phoſphorus at the end of a piece of wire be let down into this acid vapour, it immediately burſts into flame, with decrepitation, and a kind of exploſion: ſo in like manner if a few grains of the hyperoxymuriat of potaſh be put into a wine-glaſs, and twice the weight of ſtrong ſulphuric acid be added, and after that a little alcohol, ether, or oil of turpentine be poured in, an immediate and rapid inflammation will take place; the ſame effect happens with many of the readily combuſtible ſolids, particularly camphor, roſin, tallow, pitch, and caoutchouc.

So powerful is the action of this highly oxygenized acid, that it is not deſtroyed even by the preſence of water, though it is in ſome degree impeded and modified. Hence ariſes a conſiderable variety of intereſting and very beautiful experiments, from which we ſhall ſelect the two following:[g] 1. Take a long ale-glaſs, put into it a few grains of hyperoxymuriat, and then pour in water to the depth of from two to three inches; upon the ſurface of this fluid drop in a little expreſſed vegetable oil, and then by means of a long ſlender funnel, with its ſtem reſting at the bottom of the glaſs, pour in four or five times as much ſtrong ſulphuric acid as had been previouſly added of ſalt, and immediately after withdraw the funnel: the acid and ſalt will preſently react on each other, highly oxygenized muriatic acid gas will be liberated, which, paſſing through the water, enters the oil, and immediately converts it to a black frothy fluid, a multitude of ignited ſparks being diſengaged at the ſame time. 2. Take about ten grains of phoſphorus and cut it, under water, into very ſmall pieces, then put 20 grains of hyperoxymuriat into a glaſs jar nine or ten inches long, and pour in water ſufficient to half fill it; drop in the phoſphorus, and then add 40 or 50 grains of ſtrong ſulphuric acid, by means of a long funnel, as deſcribed above. As ſoon as the hyperoxymuriat begins to be decompoſed, the phoſphorus takes fire, and burns vividly at the bottom of the veſſel: on agitating the mixture, ſtreams of fire paſs rapidly to the ſurface. This experiment requires ſome precaution, for the phoſphorus is occaſionally thrown out of the veſſel in a ſtate of ignition, more eſpecially when a common wine-glaſs is uſed inſtead of a jar.

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[g] Nicholſon's Journ. 8vo. I. p. 297.

So eaſily is this hyperoxymuriat decompoſed, that when ſimply rubbed in a mortar with various combuſtible bodies, it detonates with them more or leſs forcibly: this we believe was firſt aſcertained by Mr. Hoyle,[h] and nearly about the ſame time by Vauquelin and Fourcroy. We ſhall ſelect ſome of the moſt ſtriking inſtances. Half a grain of phoſphorus and an equal quantity of the ſalt, explode almoſt immediately, with a violent report and a bright flaſh. Two grains of the ſalt and 1 of very finely pulverized and dry charcoal, produce by a ſmart ſtroke a ſtrong flame, without much report. Half a grain of dry pit-coal and 1 grain of ſalt, produce ſparks and conſiderable reports. One grain of the ſalt and three-fourths of a grain of ſulphur, produce one very loud exploſion; when the ſulphur is reduced to a quarter of a grain, there are produced by a long ſmart ſtroke with the peſtle, ſeveral ſmall ſucceſſive exploſions. One grain of the ſalt and an equal weight of alkaline ſulphuret, produce a very loud exploſion with flame; it is remarkable however that this mixture, when melted over the fire, merely emits a flaſh without any report, in which it differs materially from the fulminating powder made with nitre and ſulphuret. One grain of white ſugar and 2 of the ſalt, produce a number of ſucceſſive reports, like the loud crack of a whip. A ſimilar effect is occaſioned by rubbing a few grains of the ſalt with as many drops of ſpermaceti oil, olive oil, and various eſſential oils, particularly oil of turpentine, alſo with camphor, roſin, or indigo. If ſulphuric acid is poured on any of the foregoing mixtures previous to detonation, a copious flame, but without much noiſe, is emitted. The loudneſs of the exploſion in the above caſes is materially influenced by the degree of friction, hence if the ingredients, after being thoroughly mixed by ſlight friction in the mortar not ſufficient to produce decompoſition (which may be effected in all caſes except when phoſphorus is employed) are then wrapped in a piece of tin-foil, and ſtruck on an anvil with a cold and heavy hammer, the violence of the exploſion will be remarkably increaſed, and ſeveral ſubſtances may be thus inflamed, which remain unaltered when ſimple friction is had recourſe to; ſuch are cotton wool, certain of the metallic ſulphurets, and almoſt all the metals.

Hyperoxymuriat of potaſh is chiefly uſed in the laboratory, where it is employed in the preparation of the pureſt oxygen gas. A few grains of it ſtirred into an ounce of common muriatic acid, form a uſeful extemporaneous bleaching liquor, for various purpoſes. It has been attempted in France to compoſe a gunpowder of this ſalt, inſtead of nitre, but without ſucceſs; the mixture exploded while it was grinding, and killed two perſons who were ſtanding near.

HYPEROXYMURIAT OF SODA.[a]

This ſalt is prepared in the ſame manner as the former, by ſubſtituting ſoda for potaſh, and with the ſame phenomena. It is very difficult to obtain it pure on account of its ſolubility in water being little different from that of muriat of ſoda. It is ſoluble in three parts of cold, and ſomewhat leſs of boiling water, and is ſlightly deliqueſcent. It is alſo ſoluble in alcohol, and appears to render muriat of ſoda alſo ſoluble in the ſame menſtruum. By repeated ſolutions and cryſtallizations in alcohol it may however be obtained (though with great difficulty) in a ſtate of purity. It cryſtallizes in cubes, and produces a ſenſation of cold in the mouth. It is decompoſable with decompoſition of the acid by the ſame ſubſtances and in the ſame manner as the former ſpecies. Its baſe is abſtracted only by potaſh. It is compoſed of

66.2	Hyperoxymuriatic acid
29.6	Soda
4.2	Water
100.0	

It is made no uſe of.

HYPEROXYMURIAT OF BARYTES.[a]

The earthy hyperoxymuriats are not ſo eaſily prepared as the alkaline ores, on account of the inferior affinity ſubſiſting between their ingredients, and the inferior ſolubility of the baſes. To prepare the preſent ſalt the Woulfe bottles ſhould be charged with pure barytes, diffuſed in warm water, and a current of oxymuriatic acid gas ſhould be paſſed through the liquor till compleat ſaturation. This ſalt is ſoluble in four parts of cold and a quantity of warm water. It cryſtallizes like the muriat of barytes and can only be obtained pure by boiling the entire liquor with phoſphat of ſilver diſſolved in diſtilled vinegar; the muriat of barytes and phoſphat of ſilver mutually decompoſe each other, and form two inſoluble ſalts, while the hyperoxymuriat is not affected. This ſalt has the ſame properties as the preceding, and is compoſed of

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[h] Mancheſter Phil. Trans. V. p. 233.

[a] Chenevix, in Phil. Trans.

[a] Chenevix.

47.	Hyperoxymuriatic acid
42.2	Barytes
10.8	Water
100.0	

It is not uſed.

HYPEROXYMURIAT OF STRONTIAN.[*]

This ſalt is prepared in the ſame manner as the foregoing, and is ſeparated, like that, from the ſimple muriat by phoſphat of ſilver. It cryſtallizes in needles, is deliqueſcent, and is more ſoluble in alcohol than the muriat of ſtrontian. It melts in the mouth immediately, and produces cold. It is compoſed of

46.	Hyperoxymuriatic acid
26.	Strontian
28.	Water
100	

It is not uſed.

HYPEROXYMURIAT OF LIME.

This ſalt is obtained pure in the manner already deſcribed. It is extremely deliqueſcent, and melts at a very gentle heat in its water of cryſtallization. It is very ſoluble in alcohol, has a ſharp bitter taſte, and produces much cold in the mouth. It conſiſts of

55.2	Hyperoxymuriatic acid
28.3	Lime
16.5	Water
100.0	

Although the pure ſalt is not made uſe of, yet the entire liquor formed by ſaturating a very thick milk of lime with oxymuriatic acid gas, is extenſively employed as a bleaching material by the callico printers. It is ſaid to bleach effectually the unprinted ground, without touching the coloured pattern, and this no doubt is apparently the caſe, but the remarkable fugitiveneſs of the colours of modern printed callicoes is in all probability to be mainly attributed to the ſubſtitution of this more ſpeedy method of colouring, to the old and more tedious, but ſafer mode.

HYPEROXYMURIAT OF MAGNESIA.

The manner of preparation, and the chemical and phyſical properties of this ſalt, are nearly the ſame with thoſe of the preceding. It is compoſed of

60	Hyperoxymuriatic acid
25.7	Magneſia
14.3	Water
100.0	

HYPEROXYMURIAT OF ALUMINE.

Pure and recently precipitated alumine, when treated in a Woulfe's apparatus, in the manner already mentioned, is diſſolved; and upon pouring ſulphuric acid into the liquor, a ſtrong odour of hyperoxymuriatic acid is perceptible. This ſalt however cannot be obtained in a ſeparate ſtate.

It is made no uſe of.

P

PALLADIUM. See PLATINA.

PARTING

Is a term uſed by aſſayers, to expreſs the ſeparation of gold from ſilver. For an account of this proceſs, ſee ASSAY, and GOLD, *Purification of.*

PASTEL. See WOAD.

PEARL. See SHELL.

PEARLASH. See CARBONAT OF POTASH.

PEARLSPAR. See BRAUNSPATH.

PEAT.

Peat, or turf as it is called by ſome, is a congeries of vegetable matter, in which the remains of organization are more or leſs viſible, conſiſting of trunks of trees, chiefly oak, fir, birch, alder, hazle, and willow; of leaves and fruits, particularly hazle nuts; and of long ſtringy fibres, which appear to be for the moſt part the remains of the ſphagnum paluſtre, and other aquatic moſſes. It occurs for the moſt part in extenſive beds called peat moſſes, either occupying the ſurface of the ſoil, or covered to the depth of a few feet with ſand, gravel, and other alluvial matters. It is met with abundantly in the Northern and in ſome of the central diſtricts of Europe, in all moiſt uncultivated mountainous tracts, as high as vegetation extends; it is alſo frequent in low vallies and fenny plains; and in ſeveral parts of the Weſtern ſhore of Great-Britain runs into the ſea, to an unknown extent, as in the harbour of Oban in Argyleſhire; in Lancaſhire, a little to the North of Liverpool; and near Towyn in Merionethſhire. The depth of peat moſſes is very various, from a few feet to twelve or fifteen yards, or even more. The conſiſtence of peat is equally various, being ſometimes in a ſemifluid ſtate, forming a black impaſſable wilderneſs, ſtudded here and there by tufts of ruſhes: when more ſolid, it is ſcantily covered over with heath and coarſe graſſes, and is then paſſable by ſheep and other larger animals, eſpecially during the dry ſeaſon of the year. In all deep peat moſſes, it is found that the upper part of the peat is looſer, of a lighter colour, and leſs inflammable than that which forms the lower part of the bed. When of a good quality it is moderately compact, and may readily be cut into ſolid maſſes, like bricks, with a ſharp thin ſpade: if it manifeſts any conſiderable degree of elaſticity and reſiſtance to the ſpade, its quality is always found to be very inferior. By expoſure to the air it dries ſlowly, being very retentive of moiſture, acquires a browniſh-black colour, becomes moderately hard, and in this ſtate is very inflammable. By the further action of the weather it by degrees falls to pieces and is decompoſed, though very ſlowly. When kindled in an open grate the beſt kind burns with a yellowiſh-blue flame almoſt like charcoal, and a leſs quantity of ſmoke than wood affords; it gives out a great quantity of heat, and is reduced to light aſhes of a white or reddiſh yellow colour. Some varieties of peat are conſiderably changed with iron pyrites, on which account they effloreſce and vitriolize when expoſed to the air, and in burning give out a ſtrong ſulphureous odour, much ſmoke, and little heat, and afford a heavy reddiſh-brown aſh. Sulphats of ſoda and magneſia are alſo occaſionally found in peat, and produce a ſimilar bad effect on it, conſidered as a combuſtible, as pyrites does.

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[*] Chenevix.

By digeſtion in boiling water, peat affords a deep brown ſolution, ſlightly bitter to the taſte, and containing an uncombined vegetable acid conſiderably reſembling the ſuberic, with a portion of extract, and a little ſulphat.

By dry diſtillation there comes over a watery ammoniacal liquor, an empyreumatic oil, and carburetted hydrogen, a conſiderable quantity of charcoal remaining in the retort.

Many ingenious attempts have been made, eſpecially in France and Germany, to ſubſtitute with economy the charcoal of peat for that of wood, for culinary and metallurgical purpoſes, and it ſeems to be ſatisfactorily proved that a given bulk of the former burns ſomewhat longer, and affords a more conſiderable heat, than of the latter; but that it is incapable of withſtanding the action of a forge bellows, and is apt to deteriorate the quality of iron that is ſmelted with it. Another objection however occurs to the employment of peat charcoal on the ſcore of its being leſs economical, except in very particular circumſtances, than wood charcoal. It cannot be prepared in the manner of common charcoal, on account of its looſe texture, without a prodigious loſs of ſubſtance and deterioration of quality; the manufacturer muſt therefore have recourſe to diſtillation in iron cylinders or other veſſels, but to effect this, ſo large a quantity of peat muſt be conſumed as fuel, that the value of the charcoal, the oil, and ammonia, will hardly cover the expence. Hence it is that all the eſtabliſhments in France for this purpoſe, though of conſiderable magnitude, and carried on with vigour and intelligence, have been entirely abandoned.

In this country peat is the common fuel of a large part of Wales and Scotland, and of many diſtricts in England, where coal is not readily to be procured. It is employed not merely for domeſtic purpoſes, but for burning lime and bricks; and its aſhes, though deſtitute of alkali, are in high eſtimation as a manure, being applied for the moſt part in the form of a top-dreſſing.

PECHBLENDE. See Uranium.

PECHSTEIN. See Pitchstone.

PELICAN, an article of chemical apparatus. See Appendix.

PERIDOT. See Chrysolite.

PERIDOT *granuliforme* (of Hauy). See Olivin.

PERLSTEIN. *Wern.* Pearlſtone. *Jameſon.* Its colours are pearl and ſmoke-grey, yellowiſh-grey, fleſh-red, and reddiſh-brown, alſo greyiſh-black. It occurs in round and longiſh veſicles. Its luſtre is ſhining and pearly. Its fracture is ſmall, and imperfectly conchoidal. It is compoſed of thin concentric lamellar concretions. It is tranſlucent on the edges, eaſily frangible and ſoft. It is compoſed according to Klaproth, of

75.25	Silex
12.	Alumine
1.6	Oxyd of iron
4.5	Potaſh
2.5	Lime
2.5	Water
98.35	

It occurs in porphyry, and often contains balls of obſidian. It is found near Tokay in Hungary.

PETROLEUM. See Bitumen.

PETROSILEX. See Hornstone.

PEWTER. An alloy of Tin, which ſee.

PHARMACOLITE.[a] Chaux arſeniatée. *Hauy*.

The colour of this mineral is ſnow-white; it occurs in ſmall cryſtals occaſionally priſmatic, but more commonly acicular; ſometimes the cryſtals are aggregated into bundles, and ſometimes into maruilated maſſes. Internally it is gliſtening, with a ſilky luſtre. Its fracture is radiated or divergingly fibrous; it alſo preſents large and ſmall granular diſtinct concretions. The cryſtallized varieties are tranſlucent. It is very tender, and eaſily frangible.

It is ſoluble in nitric acid without efferveſcence. By the action of the blow-pipe it diſengages an arſenical odour, and leaves an involatilizable reſidue. By the experiments of M. Selb, it was firſt aſcertained to be a compound of lime and arſenic acid, with a little cobalt; a reſult which has been fully confirmed by a compleat analyſis of it by Klaproth.[b]

One hundred grains of this mineral, according to the celebrated chemiſt laſt mentioned, loſe by being moderately heated, and without the diſengagement of any arſenical or other odour, or viſible vapour, 22.5 grains, which are water of cryſtallization. The reſidue by digeſtion in nitric acid is diſſolved, except 6 grains, which are a mixture of ſilex and alumine. The nitrous ſolution affords with acetite of lead, a copious precipitate of arſeniat of lead, which, when waſhed and dried, weighed 138 grains, and indicated 46.5 of arſenic acid. The remaining fluid, with the waſhings, was moderately evaporated, and treated with a little muriatic acid, to ſeparate the ſmall portion of acetited lead which it contained, and was then mixed with ſulphuric acid: this produced a large depoſit of ſulphat of lime, which after being waſhed with dilute ſpirit of wine, and heated to redneſs, weighed 54 grains, and therefore contained 23 grains of lime. The reſidual liquor being neutralized by carbonated ſoda, and evaporated to dryneſs, was rediſſolved in water, and left behind 0.5 grs. of a blue powder, which tinged borax of a deep blue colour, and was oxyd of cobalt. Hence 100 parts of pharmacolite contain

46.5	Arſenic acid
23.	Lime
0.5	Oxyd of cobalt
6.	Silex with alumine
22.5	Water
98.5	

Of theſe the firſt three ingredients appear to be the only ones neceſſary to the conſtitution of this mineral.

It has been found near Wittchen, in Swabia, in a vein of granite, accompanied by heavy ſpar and gypſum. It has alſo been met with at St. Marieaux-mines in France.

PHLEGM. This term has long been uſed to ſignify the mere watery part which riſes in many compound diſtillations. Thus the firſt product from oil of vitriol when heated, is an acidulous *Phlegm*.

PHLOGISTON. All that we think it neceſſary to ſay on this merely theoretical ſubject, will be found under the article *Oxygen*.

PHLOGISTICATED AIR. See AZOT.

PHLOGISTICATED ALKALI. See PRUSSIAT *of Potaſh*.

PHOSPHORUS. *(Kunckel's)*

Phoſphorus is a ſimple ſubſtance, much reſembling wax in conſiſtence, when pure nearly of the tranſparency of gum copal, of a colour varying from amber red to the fainteſt ſtraw, highly combuſtible, and when oxygenated producing a ſtrong and peculiar acid.

It was diſcovered by a German chemiſt of the name of Brandt about 150 years ago, and the preparation was long kept a lucrative ſecret in the hands of a few perſons, but as it was generally known to be prepared from human urine, and as the method then employed, though tedious and diſguſting, was extremely ſimple, it was detected by ſeveral chemiſts, and the real nature of phoſphorus has been gradually explained by a vaſt number of ingenious and elaborate reſearches.

The earlieſt mode of preparing phoſphorus[a] was the following: a large quantity (amounting to ſeveral gallons) of human urine was collected, and after remaining for a time to become putrid it was evaporated to dryneſs in any ſuitable veſſel. The reſidue conſiſts of the animal extractive matter and of many ſalts, *(for which ſee the article Urine)* among which are two with phoſphoric acid, the phoſphats of ſoda and of ammonia. This reſidue was then mixed with charcoal in powder, and heated gradually to low redneſs in an iron pot, by which the animal matter was deſtroyed, till the maſs began to ſend forth blue luminous vapours. It was then removed into a coated earthen retort with a receiver, and heat applied gradually till it reached the utmoſt intenſity, during which the phoſphorus diſtilled over and partly concreted in the neck of the retort, and partly fell in drops into the receiver. This, which was at firſt black and foul was purified by melting, and was formed into ſticks, which were long ſold at a very high price as a great

[a] Brochant II. p. 523.

[b] Klap. Analyt. Eſſ. II. p. 220.

[a] Macquer, Chem. Dict.

philoſophical curioſity, for making luminous writing and other entertainment.

In this proceſs the quantity of phoſphorus yielded was exceſſively ſmall compared to that of the urine employed, for of all the conſtituents of urine it is only the phoſphat of ammonia that is concerned in the production of phoſphorus, the heat driving off the ammonia, the phoſphoric acid is left without a baſe, and it is then decompoſed by the charcoal which abſtracts its oxygen, and leaves the phoſphorus uncombined and volatilizable by the heat. The phoſphat of ſoda of the urine is not altered.

After a while Margraaf, an excellent chemiſt of Berlin[b] found that the product of phoſphorus was much augmented by adding to the extract of urine ſome of the *plumbum corneum*, or ſubmuriat of lead, left after diſtilling ſal ammoniac and litharge, the reaſon of which is found to be that this ſalt decompoſes (in part at leaſt) the phoſphat of ſoda of the urine, which hitherto had been uſeleſs, forming a phoſphat of lead, which is equally decompoſable by charcoal with the phoſphat of ammonia.

This method has been ſtill further improved of late years by Giobert of Turin, whoſe proceſs for preparing phoſphorus from urine we may mention here, though it is not the one generally employed. It is the following: into a quantity of urine pour a moderately dilute ſolution of acetite or nitrat of lead, which will immediately produce a copious greyiſh white precipitate of phoſphat of lead, and add the metallic ſolution as long as it produces any conſiderable milkineſs. Run the whole through a linen filter, and immediately mix the phoſphat of lead that remains with a fourth of its weight of finely powdered charcoal, (the exact proportions of each being of no great conſequence) and dry the black paſty maſs in an iron pot heated barely red. Then transfer it to an earthen retort, and raiſe the heat to moderate redneſs. Much fetid ammoniacal oily vapour paſſes over at firſt, and till this diſappears the heat is not to be raiſed higher than to a low red. Then change the empty receiver for one half full of water, or dip the elongated beak of the receiver about an inch under water, and encreaſe the heat to a full glowing red, and in about half an hour the phoſphorus diſtills. The particular management of the proceſs and ſubſequent refining of the phoſphorus are the ſame as are employed in the more common proceſs, and will be preſently deſcribed. When all is finiſhed, the retort will contain the lead reduced, and mixed with the undecompoſed charcoal, but as ſome chemiſts aſſert, it is in the ſtate of phoſphuret of lead. The average quantity of phoſphorus yielded is found to be about 14 to 18 parts from 100 of the phoſphat of lead well waſhed and dried, but this is not neceſſary, as the other urinous matters that adhere to it are readily diſperſed in the diſtillation. It does not appear to require ſo intenſe a heat to obtain phoſphorus in this way as in that which will be next deſcribed. The ſalts of zinc added to urine produce alſo a precipitate which is the phoſphat of zinc, and ſome phoſphorus may be procured from it by diſtillation, but much leſs than from the phoſphat of lead: as the zinc riſes in diſtillation along with the phoſphorus, and phoſphuret of zinc concretes in the neck of the retort.

Whilſt phoſphorus was prepared in the old way by evaporating urine, it was a very diſguſting, tedious, and ſomewhat difficult proceſs, but it was ſoon diſcovered (by Gahn, as is commonly ſaid, but as appears from ſome authority, more probably by Scheele) that the phoſphoric acid was contained in abundance in the white earth left after the calcination of BONES, united with lime, and when ſeparated by chemical means phoſphorus could be prepared from it with much more eaſe and certainty. This method is now almoſt univerſally preferred, as it requires but little apparatus, and is in no way offenſive nor difficult. The earth of bones conſiſts of phoſphat of lime, (mixed with a little carbonat) and as the ſulphuric acid has a ſtronger affinity for lime than the phoſphoric, it is this which is employed for procuring the phoſphoric. This proceſs of making phoſphorus conſiſts of two diſtinct operations, viz. the ſeparation of the phoſphoric acid from the bone-aſh, and the diſtillation of the acid and charcoal to obtain the phoſphorus: it is performed in the following manner, with ſome ſlight variations. Take any quantity (ſuppoſe 4 lbs.) of powdered bone-aſh, or calcined earth of bones, ſuch as cupels are made of, put it into an earthen pan capable of holding 4 gallons, mix it at firſt with about 4 quarts of water, and then add gradually with inceſſant ſtirring, 2 lbs. of ſtrong ſulphuric acid. A very great heat is excited by the mixture, and ſome effervefcence, (which laſt ariſes from the carbonat of lime,) and it ſhould be prevented from clotting by rapid ſtirring. Then add about a gallon of water and allow it to remain for a day with occaſional ſtirring.

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[b] An. Chim. Tom xii.

The mixture thickens extremely by ſtanding, ſo that if this quantity of water is not ſufficient, more muſt be added to bring it down to the conſiſtence of thick ſoup. Then pour the whole mixture on a linen bag, by which the clear liquor will run through, and leave the white pulpy maſs on the filter, which muſt be ſtrongly preſſed and then waſhed with a pint or two of boiling water to extract all the acid. Unite all the liquors together, and after they have ſtood a little to become quite clear they are fit for evaporation. This liquor now contains almoſt all the phoſphoric acid of the bone-aſh, chemically united with a portion of undecompoſed phoſphat of lime, and alſo holding ſome ſulphat of lime in ſolution. The white maſs in the filter is ſulphat of lime, which may be thrown away. The liquor may be either boiled down immediately, or as Dr. Higgins recommends, firſt ſaturated with ammonia and then evaporated. The former is the commoneſt method, and where the object is only to procure phoſphorus and not pure phoſphoric acid, it is probably preferable. The boiling down of this large quantity of acid liquor is tedious. It may be done either in large Wedgewood-ware evaporating pans over charcoal, or in a copper pan, as this acid does not readily act on copper. Keep up a briſk heat and continue the boiling almoſt to dryneſs, during which the clear liquor as it becomes concentrated will be muddy from the ſeparation of ſelenite, and a greaſy looking paſty acid maſs will depoſit on the ſides of the veſſel. When the liquor is boiled down nearly to dryneſs, carefully add to it the ſcrapings from the ſides of the veſſel and let it ſtand ſome hours that all the ſelenite may be precipitated. Then rediſſolve the whole in as little cold water as will take up all the acid, filter it off from the ſelenite, and evaporate it till it becomes a paſty puffy maſs, which is now intenſely ſour and conſiſts of phoſphoric acid holding ſome phoſphat of lime. Then mix it thoroughly with a fourth of its weight of powdered charcoal, and dry the whole in any veſſel with a heat juſt below redneſs. It is then fit for the ſubſequent proceſs of diſtillation.

Dr. Higgins recommends the following management of the liquor ſeparated from the ſelenitic maſs by filtration:[c] ſaturate it with carbonat of ammonia, and boil, which will cauſe the ſeparation of all the remaining earth; then evaporate the clear liquor in a leaden boiler till it is reduced ſo far that cryſtals of phoſphat of ammonia will depoſit by cooling. Pour this ſolution while hot, into a thin glaſs balloon, cover the mouth looſely with an inverted pot, and heat the balloon ſlowly till the bottom is obſcurely red. A copious ſublimate ariſes, conſiſting of ſulphat of ammonia, with moſt of the ammonia by which the phoſphoric acid was neutralized, and the latter acid (not being volatilizable by any heat) remains in the form of a colourleſs tranſparent glaſs, eaſily ſeparable from the veſſel by the blow of a hammer. It is phoſphoric acid in great purity, containing probably nothing but a little remaining ammonia. This is then powdered in a mortar and thoroughly mixed with about half its weight of charcoal, and is then fit for diſtillation.

The proceſs of diſtilling phoſphoric acid and charcoal to obtain phoſphorus is in itſelf very ſimple, but ſome precautions are required in the management. Phoſphoric acid by itſelf vitrifies in a red heat and is not further changed by any intenſity of fire, but when in contact with any carbonaceous matter it is decompoſed, yielding its oxygen to the charcoal, whilſt the phoſphorus flies off in the form of vapour, which is condenſed when it arrives at a cooler place and concretes into a brown-red waxy matter. A very ſtrong red or red-white heat is required for this purpoſe, (probably about the degree ſufficient to melt copper) ſo that the retort muſt be of earthen-ware and fitted to a powerful reverberatory furnace, or ſurrounded with burning charcoal in conſiderable maſs and heaped up for ſome height above its neck. As at this temperature the common crucible ware becomes very porous, much of the vapour of the phoſphorus would ooze through (even without any accidental flaws or cracks) ſo that the retort ſhould previouſly be coated with a vitreſcent lute, of which there is none better than ſlacked lime brought to a moderately thin conſiſtence by a ſaturated ſolution of borax in water, and bruſhed over the outſide of the retort and ſlowly dried. This when heated forms a thin glazing which ſtops up moſt of the pores of the veſſel. In the diſtillation the contact of the external air muſt be carefully excluded, otherwiſe the phoſphorus as ſoon as formed would take fire and conſume ſpeedily. This is prevented ſimply by elongating the neck of the retort with another earthen or metal tube cemented to it by *glue lute*, (*ſee the article Cement*) and dipping the end of the ſecond tube about an inch in a pan of water. Thus all the gaſſeous products paſs through the water, and the phoſphorus partly concretes within the tube and partly falls to the bottom of the water.

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[c] Higgin's Minutes. p. 252.

The proportion of one part of charcoal to two (by weight) of the concrete acid, is much more than is neceſſary to decompoſe the acid, but it is uſeful to have an exceſs of charcoal to protect the retort from being corroded by the acid, which operates as a powerful flux for all earthy mixtures.

The retort being filled with the mixture of charcoal and acid, (which may be done nearly to the neck in caſe the acid be thoroughly dried previouſly in a low red heat) put it into the furnace and raiſe the heat very gradually to a moderate redneſs. At firſt with the air of the veſſels a quantity of mixed gaſſes, chiefly carbonic acid and hydrocarbonate, paſs over, and when theſe have nearly ceaſed, increaſe the heat to a full glowing white-red and keep it up to this degree during the remainder of the diſtillation. The firſt indication of the production of phoſphorus is that the gas as it paſſes out of the water becomes white and luminous in the duſk, which is followed by a gas ſtill more inflammable, each bubble of which takes fire in the air and burns with a brilliant flame and ſlight ſnapping noiſe as ſoon as it riſes above the ſurface of the water beneath which the end of the tube is dipped. After this the phoſphorus riſes in ſubſtance, and if the quantity of materials in the retort be large, ſome of it falls down in drops into the pan of water, where it immediately congeals, but by far the greater part concretes in that part of the neck of the retort which reaches out of the furnace, and in the tube by which it is elongated. Sometimes the paſſage is entirely blocked up by the congealed phoſphorus which might endanger the burſting of the retort, to aſcertain which a flexible wire may be thruſt up now and then (but without raiſing the end of the tube out of the water) and if the paſſage is not free, lay a red hot iron bar on the outſide of the tube where the paſſage of the wire is obſtructed, which will melt down the phoſphorus.

It is not eaſy to aſcertain when all the phoſphoric acid is decompoſed, and all the phoſphorus has paſſed over, for the efflux of gas nearly ceaſes before the diſtillation is compleated, ſo that experience muſt guide the operator when to ſtop. If the retort continues ſound, no loſs of phoſphorus is incurred by continuing the fire longer than neceſſary, ſo that it is better to exceed than to fall ſhort of the requiſite time. But as earthen veſſels will ſooner or later vitrify and ſink down in a very ſtrong heat, the fire ſhould be kept below the degree at which earthen fire-veſſels ſoften, and the retort ſhould be now and then examined. Sometimes the retort unfortunately cracks in the middle of the diſtillation, which may be diſcovered by a bright green flame and a denſe white ſmoke around the part that has given way. This may ſometimes be cloſed by immediately preſſing on the part ſome linſeed oil fire lute, *(as deſcribed in the article Cement)* but if this fails the retort muſt be taken out, and as much of the materials as poſſible ſaved for a future operation.

When the diſtillation is judged to be finiſhed, remove the tube from the water and inſtantly cork it tightly to prevent the acceſs of air, which would inflame the phoſphorus, and let the retort cool. When quite cold break it with a hammer juſt where the neck joins with the body of the veſſel, holding it in the ſame poſition as it ſtood in the furnace, to prevent the charcoal within the retort from mixing with the phoſphorus ſublimed in the neck and tube, and throw the latter into cold water. The phoſphorus may then be got out by removing the tube into boiling water, which melts out the phoſphorus, but in this as in all operations on this inflammable material whenever a ſufficient heat to melt it is applied, (which is about 100°) every thing ſhould be done under water, as it kindles a little above its melting temperature, and burns vehemently the moment it becomes expoſed to the air.

The phoſphorus produced in this proceſs is very brown and foul, and is mixed with a good deal of a brown red powder which diffuſes itſelf in water like clay, and conſiſts chiefly of phoſphorus ſo far oxygenated as to be no longer combuſtible.

The quantity of product varies extremely, but is the moſt when the materials are dry and the diſtillation ſlow. Pelletier obtained 60 oz. of phoſphorus by a ſingle proceſs from the acid of 36 lbs. (576 oz.) of bone-aſh decompoſed by 30 lbs. of ſulphuric acid.

The brown red phoſphorus may be purified by ſeveral methods. The ſimpleſt is the following: take a piece of thin white leather, put the impure phoſphorus in the middle and tie up the ends very tight ſo as to encloſe it in a leather bag; then plunge it into boiling water and ſqueeze the bag with the fingers, by which the melted phoſphorus will ooze through in drops, that coaleſce at the bottom of the water into a clear pure waxy phoſphorus almoſt tranſparent and colourleſs. All this ſhould be done under water. What remains in the bag is a mixture of black carbonaceous matter, with a good deal of the red incombuſtible oxyd of phoſphorus already mentioned. Care muſt be taken in doing this not to get any of the phoſphorus beneath the finger nail, which might occaſion a dangerous and painful burn. The leather will not ſerve a ſecond time.

Another way is by diſtillation. Phoſphorus is perfectly volatile at a heat of about 200° and it riſes in the ſecond diſtillation quite pure and tranſparent. In doing this, all acceſs of air ſhould be prevented, as the heat required to ſublime it much exceeds that at which it takes fire in the air. The air within the veſſel is ſpeedily deoxygenated by the action of the phoſphorus at a common temperature, and of courſe no combuſtion can take place when the phoſphorus is further heated in this ſame air. Or, the phoſphorus may firſt be melted to the bottom of the retort by hot water, and the latter diſplaced by azot or hydrogen, (in which phoſphorus is equally uninflammable) and then a heat applied ſufficient firſt to melt and then to ſublime the phoſphorus.

Another mode of purifying it is to melt it in nitro-muriatic acid, and to ſhake it thoroughly in the acid, whereby on ſtanding again it concretes into a very white tranſparent maſs. The red oxyd of phoſphorus is ſeparated in this proceſs and is converted into phoſphoric acid. This method however does not appear to be ſo good as the firſt mentioned.

Phoſphorus when newly purified is nearly tranſparent and of a waxy conſiſtence, but when kept in water it ſoon becomes covered with a reddiſh-white opake cruſt. It is inſoluble in water. Its ſpecific gravity is 1.77.

The moſt remarkable phenomena relating to phoſphorus are thoſe that occur during its combuſtion. When a ſtick of phoſphorus is ſimply expoſed to the air, if the temperature be above 45°, it conſtantly ſends off a white vapour of a very ſtrong unpleaſant ſmell, ſomewhat like that of garlic, which is more copious and denſe in proportion to the temperature. This vapour in the dark is ſeen to be a blue lambent flame, and it continues to be emitted from the phoſphorus for a great length of time with little apparent alteration, and without giving out any ſenſible heat. Hence it is that if characters are traced by rubbing a ſtick of phoſphorus on a board, or any rough ſurface, they are made luminous by the minute quantity of phoſphorus abraded, when expoſed to the air. This however is a real though ſlow combuſtion, and in time the whole of the phoſphorus is partly wafted away in luminous vapour, and partly converted into acid on the ſpot, and the light ceaſes. When a piece of phoſphorus is put into a ſilver ſpoon and held near a fire or candle, the white vapour becomes extremely denſe and copious, the phoſphorus melts at about 99°, and at 148° it takes fire and burns with a very bright greeniſh white flame and heavy white ſmoke. No reſidue is left in the ſpoon, but if the ſmoke is received into any veſſel it condenſes on cooling into a very ſour liquid, which is the phoſphoric acid. Thus then it appears that there are two modes of combuſtion of phoſphorus, one a ſlow combuſtion, with ſcarcely any ſenſible heat, and in which much of the phoſphorus is ſlowly volatilized by the ſurrounding air; and the other a rapid combuſtion with vivid light and intenſe heat. The former begins at the temperature of from 40° to 45° (in the atmoſphere) and whilſt the phoſphorus remains ſolid; the latter occurs at the heat of about 148° and after fuſion. The former is not dangerous to the touch, but the latter produces a very rapid deſtruction of the ſkin and fleſh, ſo that phoſphorus ſhould always be handled with great caution, as very ſerious burns have ariſen from careleſſneſs in this reſpect.

Phoſphorus when very pure diſſolves in alcohol though very ſparingly. As it diſſolves, the liquor takes the peculiar unpleaſant ſmell of phoſphorus.[e] This ſolution is not of itſelf luminous, but if a drop of it is let to fall on a little water at the bottom of a glaſs veſſel in perfect darkneſs, the moment it touches the water a faint blue lambent flame is ſeen to undulate on the ſurface and gradually to fill the veſſel. If the air of the veſſel is changed by blowing into it, the ſame phenomenon is renewed repeatedly till all the phoſphorus is extracted from the mixture. In like manner if a wetted feather be dipped in the phoſphorized alcohol, the air above the point of contact immediately becomes luminous. In theſe experiments there appears a kind of double decompoſition, the phoſphorus uniting with the atmoſphere, and the alcohol with the water, and the heat excited by the mixture of theſe two liquors doubtleſs favours the decompoſition.

Oil of turpentine and the other eſſential oils diſſolve phoſphorus with more facility and in greater quantity than alcohol. If a little of this ſolution is ſmeared over the face or hands, the warmth of the body cauſes the oil to evaporate ſpeedily, after which the thin inſenſible pellicle of phoſphorus that remains becomes ſtrongly and uniformly luminous, and continues ſo for ſome time. This amuſing experiment is no ways hazardous, as the quantity of phoſphorus left on the ſkin is too ſmall to do miſchief.

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[e] An. Chim. tom. 24.

Phoſphorus may be equally well diſſolved in the fixed oils. Oil of olives or almonds are the moſt convenient. Heat the oil in any veſſel with the phoſphorus for about a quarter of an hour, and the oil will diſſolve enough of the phoſphorus to be extremely luminous when ſmeared over the ſkin or any warm ſurface.

Sulphuric ether diſſolves phoſphorus, but this ſolution is not of itſelf luminous. Alcohol added to it makes it milky.

The habitudes of phoſphorus with the different gaſſes offer ſeveral very intereſting phenomena. Theſe have been examined with great care by Fourcroy, Vauquelin,[f] Spallanzani,[g] Brugnatelli,[h] and others, with the particular view of refuting ſome obſervations of Goettling on the luminouſneſs of phoſphorus in azotic gas, which were ſuppoſed to militate againſt the modern theory of combuſtion.

When a ſtick of pure phoſphorus is introduced into very pure oxygen gas, no light whatever is perceived, though the experiment be made in perfect darkneſs, at any temperature below 80° or 81°. But if it be raiſed to this point by putting the warm hands on the outſide of the jar, the phoſphorus becomes very luminous, and is ſurrounded with white vapours. This appearance continues till the temperature is reduced to 55°, when it ceaſes entirely. This luminouſneſs is cauſed by a low combuſtion of the phoſphorus and conſequent generation of phoſphoreous acid, ſo that in this, as in all the ſubſequent experiments, whenever the luminous appearance has taken place litmus paper within the jar will be reddened. From 81° to 104° this ſlow combuſtion continues but with increaſing rapidity, but at about 104° the phoſphorus, which is then melted, takes fire and burns rapidly with intenſe heat and flame as already deſcribed. But though phoſphorus does not begin to be luminous, and therefore to undergo combuſtion in pure oxygen at a lower temperature than 81°, it imperceptibly diſſolves therein at the heat of 55°, and perhaps lower, as will be preſently ſhewn.

Phoſphorus introduced into perfectly pure azotic gas, (ſuch as that extracted from muſcular fleſh by weak nitric acid) is not luminous at any temperature, but may be melted and even ſublimed therein without ſhewing the leaſt light, or undergoing the ſmalleſt combuſtion. It diſſolves in it however at 55° and enlarges its bulk about $\frac{1}{40}$ according to Berthollet, as has been mentioned under the article EUDIOMETRY, (*which ſee*). But if a ſingle bubble of oxygen gas, pure or impure, be thrown up into a jar of this phoſphorized azot, a pretty ſtrong blue light is perceived at the moment of contact which continues for a ſhort time. The ſame effect, but in a much greater degree, is produced by inverting the experiment, and adding bubbles of phoſphorized azot to oxygen gas, in which caſe the whole veſſel is filled with a fine lambent blue flame. Not only pure oxygen, but common air or any other mixture of oxygen will render phoſphorized azot ſtrongly luminous. It has been mentioned that phoſphorized oxygen gas does not of itſelf become luminous till heated to 81°, but (what appears at firſt very remarkable) if a jar be filled with it and kept at the temperature of 55° and a few bubbles of azot be thrown up, the whole jar immediately ſhines with a bright blue light like that of the electric aura. It appears therefore that when phoſphorus, azot, and oxygen are preſent, the phoſphorus firſt combines with the azot, and being thus extremely divided, it is able to undergo combuſtion with oxygen at a much lower temperature than where the azot is abſent. This is exactly what takes place when phoſphorus is confined at a moderate temperature in atmoſpherical air, and hence to employ phoſphorus as an eudiometer at this heat the preſence of the azot is neceſſary to ſet in action the combuſtion.

Meſſrs. Fourcroy and Vauquelin found that when phoſphorized oxygen had been firſt made luminous by raiſing the heat to 81°, and *then* cooled to 55° and mixed with azot, no light could be perceived.

The ſame chemiſts alſo obſerve that when phoſphorized oxygen and phoſphorized azot (both made by keeping phoſphorus in the reſpective gaſſes at a low temperature for ſome hours) are mixed together at 55°, no light is perceived, which is a very ſingular fact, and appears to contradict the experiment in which azot renders phoſphorized oxygen luminous, or oxygen, phoſphorized azot, at the ſame temperature. The only difference in this caſe is that *both* gaſſes are previouſly ſaturated with phoſphorus, inſtead of only one.

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[f] An. Chim. tom. 21. [g] Do. tom. 22. [h] Do. tom 24.

When a ſtick of phoſphorus is confined in hydrogen gas no light is produced, but after a time the gas diſſolves ſome of the phoſphorus, and then, like phoſphorized azot, it becomes luminous on the contact of oxygen or any air containing oxygen. In like manner pure hydrogen added to phoſphorized oxygen renders it luminous, and even at as low a temperature as 44° according to Spallanzani.

With hydrogen, phoſphorus unites in two ſtates of ſaturation, the loweſt is that which has been juſt mentioned, and is produced by keeping phoſphorus in hydrogen at a moderate temperature. The other is the gas produced by boiling the phoſphorus in an alkaline ſolution, and will be afterwards deſcribed. The former gas is merely luminous by expoſure to air or oxygen, the latter takes fire and burns with a bright flaſh and ſlight exploſion; the former therefore may for the preſent be diſtinguiſhed by the term *ſub phoſphuretted hydrogen*, and the latter *phoſphuretted hydrogen*.

Phoſphorus kept in ſulphuretted hydrogen diſſolves therein, but is not luminous. On adding common air a large blueiſh flame is produced. This luminous gas ſeems to be more permanent and condenſed than the others, attaching itſelf to the hands or to the veſſel in which the experiment is made, and giving them a very bright luminous coating, which remains for ſeveral minutes.

No very intereſting appearance takes place when phoſphorus is confined in the other gaſſes, but when thrown into the oxymuriatic acid gas, it ſoon takes fire, and burns rapidly and beautifully.

In all the above experiments where it is aſſerted that the gas containing the phoſphorus remains abſolutely dark, it is underſtood that it is confined by mercury, for when kept over water, the oxygen which this fluid uſually contains may be diſengaged, and the minuteſt quantity will become ſenſible by ſuch a delicate teſt.

The ſolution of phoſphorus in oxygen gas at a low temperature is a very curious circumſtance, for it muſt imply a very intimate union of the two without any approach to combuſtion, ſince at any time combuſtion may be excited in the mixture either by raiſing the heat to 81°, or by adding azotic or hydrogen gas, and ſince after the temperature has been raiſed to the point of luminouſneſs and ſlow combuſtion, and again reduced, no effect is then produced by the above additions.

The ſub-phoſphuretted hydrogen having been already mentioned, we may proceed to deſcribe the phoſphuretted hydrogen. This gas was firſt diſcovered by Gengembre, who prepared it by boiling phoſphorus in alkali. It is eaſily produced in the following way: put ſome pieces of phoſphorus in a very ſmall bottle with a curved tube, or in a ſmall retort, fill the veſſel to the neck with a weak ſolution of cauſtic potaſh, and heat it to boiling, taking care to dip the open end of the bottle or the tube in water or mercury to prevent the acceſs of air. When the ſolution begins to boil, bubbles of gas riſe to the ſurface, which kindle immediately and burn with a bright flaſh within the veſſel as long as any oxygen remains. This cauſes a rapid abſorption, ſo that unleſs the veſſel is nearly full, much of the water or mercury ruſhes up, but after a while this ceaſes, and the diſcharge of gas is copious and regular. It is the peculiar property of this phoſphuretted hydrogen to burn with a very vivid flaſh and a ſlight ſnapping noiſe the moment it comes in contact with the atmoſphere, and after each bubble has thus exploded, a very remarkable circular ring of white ſmoke riſes from the flaſh, and mounts about two or three feet in the air, gradually widening till it diſperſes. This gas if received by bubbles in a jar of oxygen gas burns with a ſtronger exploſion and a brilliant flaſh of flame, perhaps more beautiful than any other that chemiſtry can exhibit. Phoſphuretted hydrogen may alſo be produced by heating phoſphorus very ſtrongly, and ſubliming it in an atmoſphere of hydrogen. Another method of producing it is ſimply by dropping into water ſome phoſphuret of lime, as will be preſently mentioned.

Phoſphuretted hydrogen has a ſtrong and unpleaſant ſmell ſomewhat like that of ſtale fiſh. It is conſiderably lighter than common air, but its compoſition ſeems to vary according to the circumſtances and time of its formation. If kept in the dark, and over mercury, it retains its inflammability for a length of time, but in the light it is ſoon changed, and no longer kindles on admiſſion of common air.

When this gas recently prepared is agitated with cold water, a conſiderable quantity is abſorbed, and a liquor is formed of a faint yellow colour, a diſagreeable ſmell and a bitter and nauſeous taſte.[1] It is not luminous in the dark. Water thoroughly purged of air by recent and long continued boiling, will abſorb at 55° about a fourth of its bulk of the gas.

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[1] Raymond in Ann. Chim. tom. 35.

When this ſolution is heated, the gas is again expelled, at a heat below boiling, unaltered, and as inflammable as before.

If the ſolution is expoſed to the air it ſoon becomes turbid, and depoſits a conſiderable quantity of red oxyd of phoſphorus, whilſt hydrogen eſcapes, which is now no longer ſpontaneouſly inflammable. In time the liquor becomes ſimply water containing a little oxyd of phoſphorus.

This ſolution of phoſphuretted hydrogen when made with well boiled water does not change the colour of litmus, and therefore is neither acid nor alkaline. It ſpeedily alters many metallic ſolutions, reducing the metal to the ſtate of a phoſphuret. This is particularly remarkable when added to the ſolutions of ſilver, mercury, and lead, which it immediately blackens and ſeparates a phoſphuret of the metal, which in time is changed to a phoſphat.

Phoſphorus ſcarcely if at all unites with any of the three alkalies at any temperature.

With lime phoſphorus unites by a moderate heat and forms a compound which has ſome curious properties. It may be made in the following manner.[k] Put into a long dry thin phial about half a dram of well burnt powdered lime, then about half this quantity of phoſphorus, and fill it with alternate ſtrata of lime and phoſphorus. Stop it looſely with a cork, and bury it to the neck in hot ſand, and keep the heat to a degree juſt below redneſs till the lime is uniformly impregnated with the phoſphorus, and is of an auburn colour. In this proceſs the phoſphorus riſes in vapour through the lime, and a part unites with it into a phoſphuret, but ſome eſcapes by the cork and burns off. When the proceſs is finiſhed, for which no exact rule can be given, preſs the cork in to prevent the air from entering in cooling, and to keep it for any length of time the bottle ſhould be inverted over mercury.

The phoſphuret if duly prepared is friable and readily broken down in the bottle when cold by an iron wire, and at this point the proceſs ſhould ſtop. If continued longer, too much of the phoſphorus is expelled, and the phoſphuret will not preſent the uſual appearances; if too little, the maſs is hard.

When a quantity of this phoſphuret is thrown into water about blood warm, it ſwells and crackles, and bubbles mount up, which take fire as ſoon as they reach the air, and burn with a bright flaſh and ſnapping noiſe on the ſurface of the water. This gas is phoſphuretted hydrogen, the properties of which have been already deſcribed.

By a ſimilar proceſs phoſphorus may be made to combine with barytes, and when melted, it exhibits the ſame phenomena.

Phoſphorus appears to unite with charcoal during the proceſs of the diſtillation of phoſphorus by charcoal and phoſphoric acid. This compound (according to Prouſt[l]) is the ſubſtance that remains in the leather bag when the impure phoſphorus has been ſtrained through it as already mentioned, but it is beſides mixed with ſome uncombined phoſphorus. It is red, and does not melt like pure phoſphorus. Diſtilled *per ſe* in a cloſe veſſel the exceſs of phoſphorus ſublimes at a moderate heat, and there remains an orange red light flocculent maſs, apparently homogenous, which this excellent chemiſt conſiders as the true phoſphuretted charcoal. If the heat is raiſed to redneſs moſt of the *combined* phoſphorus is ſublimed, and the reſidue is little elſe than charcoal.

If a little of the phoſphuretted charcoal is laid on a red hot iron plate, the phoſphorus burns firſt, and forming phoſphoric acid it melts with and involves the remaining charcoal and preſerves it from the further action of the fire. Cauſtic potaſh in ſolution boiled with this compound produces no effect upon it, which ſhews how intimate is the chemical union of the conſtituent parts. It is probably this ſubſtance that forms the red or black powder which ſo often appears in many operations with common phoſphorus.

Sulphur and phoſphorus unite in ſeveral proportions, forming a very intereſting compound, which is one of the moſt inflammable and dangerous combuſtibles that we are acquainted with. Phoſphuretted ſulphur was firſt noticed by Margraaf, afterwards by Pelletier,[m] who has ſhewn the mode of combining them, and the great fuſibility of the compound, and more lately Mr. Accum[n] and Dr. Briggs[o] have given very intereſting papers on this ſubject. From all theſe ſources the following particulars may be collected. This ſubſtance may be made by heating the phoſphorus and ſulphur in the required proportions in water till the phoſphorus melts, which ſoon diſſolves the ſulphur and forms a yellowiſh maſs, which is the compound in queſtion. Phoſphorized ſulphur melts at a much lower temperature than phoſphorus itſelf, ſo that a heat much leſs than that of boiling water will be ſufficient, and on account of the extreme riſk of exploſion when the heat is too great, no more than is abſolutely neceſſary ſhould be uſed. The fuſibility of the compound increaſes with the proportion of ſulphur. Thus Pelletier found that phoſphorus alone, liquified by heat and allowed to cool, ſolidified at a temperature of from 90° to 100°. But all the mixtures of phoſphorus and ſulphur remained fluid at a much lower temperature. The particular experiments are as follows:

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[k] Higgins.

[l] An. Chim. tom. xxxv. p. 45.

[m] Memoirs, &c. de Pelletier, tom. I.

[n] Phil. Journ. 8vo. vol. 6.

[o] Do. vol. 7.

Phoſphorus		Sulphur		
72	with	9	congeal at	77° Therm.
72	- -	18	- - -	59
72	- -	36	- - -	50
72	- -	72	- - -	41
72	- -	144	- - -	55

but when the quantity of ſulphur exceeds that of the phoſphorus the combination appears leſs perfect.

If equal parts of the two ingredients be melted under water at a heat not exceeding 180°, only a certain portion of the ſulphur unites with the phoſphorus, and the remainder may be waſhed away with cold water. This compound is yellow and friable, melts by the heat of the hand, and takes fire at about 112°. Two parts of phoſphorus and one of ſulphur are very convenient proportions for making this compound. They are to be put into a flaſk with water, and melted in a heat conſiderably ſhort of boiling, and kept for a ſhort time till the union is compleat. The veſſel ſhould on no account be ſhaken whilſt the materials are fluid, for Mr. Accum relates a moſt dangerous exploſion which took place in conſequence. Neither ſhould the water be allowed to boil in which the phoſphorized ſulphur is contained, for after a ſhort time the mixture has been known to explode with prodigious violence, and with a large volume of flame. Yet, on the other hand, Mr. Accum, in another inſtance, kept a quantity of this mixture under a pretty long column of boiling water for a conſiderable time without accident; ſo that till we are better acquainted with the preciſe circumſtances that produce exploſion of this dangerous compound, ſuch an event ſhould always be expected and guarded againſt, when the mixture is heated in water, to within a few degrees of the boiling point. This ſubſtance alſo ſhould be handled with ſtill more caution than phoſphorus, for it takes fire with a moderate heat, and even in the temperature of the air when ſlight friction is uſed.

Phoſphorus and ſulphur may alſo be ſafely combined in a cloſe veſſel without water. For this purpoſe, take a glaſs tube hermetically ſealed at one end, put into it the phoſphorus and ſulphur, both perfectly dry, cork it very tight, and plunge the tube into hot water, which is to be gradually brought to boiling. The ſulphur and phoſphorus will unite without exploſion, and when removed from the water, but ſtill fluid, the tube may be ſhaken to compleat the union, care being taken to keep it well corked all the time.

Phoſphuretted ſulphur has the property of decompoſing water without the aſſiſtance of alkalies or any other ſubſtance, a property not poſſeſſed by phoſphorus or ſulphur ſingly. The gas thus generated is a mixture of phoſphorus, ſulphur, and hydrogen, has the peculiar ſmell of both ſulphuretted and phoſphuretted hydrogen, and is luminous in the air, and if recently prepared, takes fire ſpontaneouſly, and burns with a greeniſh flame and a white ring of ſmoke. This compound gas was procured by Mr. Accum, (though not without riſk of exploſion) by putting two drams of phoſphorus with two of ſulphur into a Wedgwood-ware tube, cloſed at one end, and furniſhed at the other with a perforated cork, and bent glaſs tube fitting it, which was dipped under a jar of water. Four ounces of water were added to the mixture, and gradually brought to boil, during which nearly two quarts of the gas were procured, and without exploſion. This gas was ſoluble in about four times its bulk of water by agitation. On throwing up common air to the gas, an inſtantaneous inflammation enſued, the veſſel became filled with white fumes, and was ſoon lined with a white cruſt, which attracted moiſture rapidly, and conſiſted of ſulphur, ſulphuric, and phoſphoric acid. A conſiderable detonation is produced when this gas is mixed with the oxymuriatic acid gas.

The decompoſition of phoſphuretted ſulphur by water, takes place, though ſlowly, at a heat, ſcarcely higher than that of the atmoſphere.

This compound (compoſed of three parts of phoſphorus and one of ſulphur) rapidly abſorbs oxygen from the air, ſo that it may be employed with advantage as an eudiometer.

It is very rapidly oxygenated by nitric acid, even without heat, and converted into ſulphuric and phoſphoric acids.

Phoſphorized ſulphur is ſoluble in the fixed oils. If a little of it be rubbed in a mortar with five or ſix parts of olive oil, and then put into a phial and allowed to ſtand for ſome little time, *without applying heat*, a liquid phoſphorus is produced, which, when quite clear (ſo that none of the phoſphuret is ſuſpended in the oil) may be rubbed on the ſkin with perfect ſafety, and ſhines with much more brilliance than the ſolution of ſimple phoſphorus in oil. Equal parts of this phoſphuret in olive oil and oil of turpentine when ſhaken together and poured out of a veſſel, gives in the dark the appearance of a beautiful ſhower of fire.[p]

The eſſential oils alſo diſſolve this phoſphuret and produce luminous ſolutions.

Phoſphorus unites with moſt of the metals, forming compounds, which are all brittle, and moſtly of a greyiſh-white colour. Theſe phoſphurets may be made either by heating the metal (in ſhreds or powder) with a mixture of phoſphoric acid and charcoal; or by projecting phoſphorus on the metal when red-hot. The phoſphorus burns off from moſt of the metallic phoſphurets by heating in the open air. They are individually deſcribed under the reſpective metals.

PHOSPHORIC AND PHOSPHOREOUS ACID.

The product of the combuſtion of phoſphorus (or oxygenation in any other way) is an acid, which, though compoſed merely of phoſphorus and oxygen, differs in a notable degree according as the oxydation is more or leſs compleat. When incompleat, the *phoſphoreous* acid is produced; when compleat, the *phoſphoric* acid, ſo that of theſe two ſubſtances, the former contains more phoſphorus or leſs oxygen than the latter. Some chemiſts have rather ſuppoſed that the phoſphoreous acid is the phoſphoric, holding ſome uncombined phoſphorus in ſolution (in the ſame way as the *nitrous* acid may be conſidered as the *nitric*, holding diſſolved nitrous gas) that is to ſay, that all the oxygen of the phoſphoreous acid, is combined with a part only of the phoſphorus, and in the proportions in which phoſphoric acid is conſtituted, and that the ſuperabundant phoſphorus of the phoſphoreous acid is only in looſe combination with the remainder. Perhaps this is the proper way of conſidering this ſubject, for though the phoſphoreous acid cannot be made by digeſting phoſphorus in the phoſphoric acid, the former acid may be converted into the latter by mere heat, which drives off the exceſs of phoſphorus.

The Phosphoreous Acid is produced by the *ſlow* combuſtion of phoſphorus in atmoſpherical air, or that which is excited at all the common temperatures at which phoſphorus becomes ſimply luminous without burſting into flame. It may be ſafely performed in ſmall quantities at any heat below the melting point of phoſphorus. The phenomena attending the ſlow and the rapid combuſtion of this ſubſtance in common air and in oxygen, have been already fully deſcribed.

Phoſphoreous acid is conveniently prepared according to Pelletier's method. Incloſe ſticks of phoſphorus, each in a ſmall glaſs tube, quite open at one end, and drawn out to a capillary tube at the other. Arrange any number of theſe in a glaſs funnel, with the ſmaller ends of the tube downwards, and ſet the funnel in an empty glaſs bottle. The contact of the air immediately begins the ſlow combuſtion of the phoſphorus, and a luminous vapour ariſes from each tube. But if this vapour (which is phoſphorized azot in the act of union with oxygen) is allowed to diſperſe freely in the air, moſt of the phoſphorus would be wafted away and loſt; ſo that it is found neceſſary to confine it, by ſetting the bottle and funnel on a plate with a little warm water at bottom, and inverting over the whole a large bell-glaſs, with an opening in the middle, looſely corked, through which ſufficient air may be let in from time to time, to maintain the ſlow combuſtion of the phoſphorus within. In this way the phoſphorus gradually deliqueſces into a liquid acid, which falls in drops through the tube and funnel into the veſſel below. About three times the weight of the phoſphorus employed may be collected. The uſe of confining each ſtick of phoſphorus in a ſeparate tube is, to guard againſt the dangerous accident of the whole phoſphorus taking fire; for though a ſingle ſtick of it may be expoſed to any natural temperature without kindling, it has been found that when a number of ſticks are heaped together and expoſed to the air from 65° to 70°, ſo much heat is generated by the ſlow combuſtion, as to cauſe the whole to inflame, which might be productive of the moſt ſerious conſequences.

The acid which drops from the phoſphorus in this proceſs is the *phoſphoreous*, and is a tranſparent liquor of the conſiſtence of ſyrup, ſtreaky when ſhaken, without ſmell, and with a ſtrongly acid and peculiar taſte.[a] When heated in a retort, it firſt thickens by the loſs of its ſuperfluous water, after which a number of bubbles ariſe to the ſurface, and break with a white ſmoke, which is luminous in the dark, ſmells ſtrongly of phoſphuretted hydrogen, and ſometimes actually takes fire. In an open veſſel theſe bubbles kindle the inſtant they reach the ſurface. By continuing the heat for a conſiderable time, all the ſuperfluous phoſphorus is burnt off, and the liquor is now converted into *phoſphoric* acid.

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[p] Accum.

[a] Fourcroy.

The phoſphoreous acid, though not ſaturated with oxygen, does not abſorb it, either when expoſed to the air or to oxygen gas, at leaſt not till after a conſiderable length of time, which, together with the great difficulty of expelling the exceſs of baſis by heat, ſhews the very ſtrong affinity between phoſphorus and phoſphoric acid, and ſeem to confirm the opinion already ſtated, with regard to the conſtitution of the phoſphoreous acid. By boiling with nitric acid however, the exceſs of phoſphorus is compleatly oxygenated, and the whole becomes phoſphoric acid.

Phoſphoreous acid added to thoſe of the metals that diſengage hydrogen during ſolution, ſuch as iron and zinc, diſſolves them with the production of a fetid gas, luminous in the dark, but not inflammable *per ſe*, which is hydrogen, holding a very ſmall portion of phoſphorus in ſolution, or what may be termed ſub-phoſphuretted hydrogen. The reſidue is the phoſphat of the metal employed.

This acid mixes with water in all proportions, and cannot be rendered ſolid by evaporation without loſing the exceſs of phoſphorus, which diſtinguiſhes it from the phoſphoric.

The combinations of this acid with the ſeveral baſes, form the *phoſphites*, which will be preſently deſcribed.

Phosphoric Acid.

This acid is found native in ſeveral ſtates of combination, particularly with lead and with lime, and it compoſes a great part of the earth of bones (whence it may be extracted in the way already mentioned), but it is never found native uncombined with any baſe. There are two methods of preparing it, one directly from phoſphorus, the other by the decompoſition of phoſphat of lime. The former gives it more certainly in a ſtate of abſolute purity.

Phoſphoric acid is produced by the *rapid* combuſtion of phoſphorus in oxygen, which may be done either over mercury or water. After combuſtion, which gives intenſe heat and light, the acid ſublimes in white cryſtalline flakes, that concrete on the inner ſurface of the veſſel, and which ſoon deliqueſce into a very ſtrong acid. If this is done over water, it ſhould be over a very thin ſtream of this fluid, and then by waſhing out the jar with it, all the acid mixes with the water, and may be concentrated by evaporation.

Another and very convenient way of preparing it is, by compleating the acidification of phoſphoreous acid by the nitric, as mentioned in the former article. Let phoſphoreous acid be prepared either by the ſlow combuſtion of phoſphorus, or elſe in the following way, which is very convenient. Put a quantity of pure phoſphorus in a ſmall cup, which will not crack by the heat, ſtanding in a plate, the bottom of which is covered with water: kindle it, and immediately whelm over it a large bell-glaſs, which, as in the combuſtion in oxygen, will ſpeedily be lined with the concrete acid. When the flame has gone out and the veſſel is cold, lift up the jar to change the air within it, and again fire the phoſphorus as before. When this has been repeated a number of times, waſh all the inſide of the jar with the water of the plate, and evaporate this in the open air till it begins to ſend forth bubbles which flaſh as they break; then add nitric acid till no more red nitrous vapours are perceived, and complete the evaporation nearly to dryneſs. The reſidue is pure phoſphoric acid. The oxymuriatic acid may be uſed inſtead of the nitric.

Phoſphorus alſo may be compleatly oxygenated by boiling with the nitric acid without the aſſiſtance of previous combuſtion, and this is perhaps the ſhorteſt and beſt way of preparing it. For this purpoſe put about ſix parts of moderately ſtrong nitric acid into a retort, heat it and then drop in one part of pure phoſphorus. A violent diſengagement of red nitrous vapour takes place, and when it has ceaſed, boil the liquor till all action between the two appears to be over. Then evaporate the ſolution nearly to dryneſs, and the reſidue is pure phoſphoric acid.

This acid may alſo be prepared from phoſphat of lime in conſiderable purity, by means of ſulphuric acid and *ammonia* in the way given by Dr. Higgins, and already mentioned under the article *Phoſphorus*.

It was found by Lavoiſier that 100 parts of phoſphorus, during combuſtion in oxygen gas, abſorbed 154 of oxygen, and produced 254 of concrete phoſphoric acid; which proportions have been confirmed, or nearly ſo, by other chemiſts.

Phoſphoric acid, in whatever way prepared, has the following properties: When concentrated as much as poſſible, retaining the liquid form, it is a thick unctuous-looking fluid of the ſpecific gravity of 2, or ſometimes more, ſtrongly acid but with no other taſte, nor any ſmell. It is capable of the concrete form under certain circumſtances. When produced by combuſtion in the way already mentioned it appears in cryſtalline flakes but very deliqueſcent: the liquid acid alſo when of 2· ſp. gr. if kept for ſeveral days at 32° or thereabouts will gradually depoſit ſmall needled cryſtals.[a] Even in ſummer this takes place when quite at reſt, but in a longer time.

Phoſphoric acid is entirely unaltered and fixed in the fire. When the liquid acid is heated, it firſt parts with its water, then, continuing the heat, it becomes a clear gelatinous maſs, and at laſt when the heat is raiſed to redneſs it bubbles and ſwells, and finally ſettles into a clear colourleſs acid glaſs. This however is again ſoluble in water and returns to its former ſtate. The gelatinous acid is extremely deliqueſcent, and the vitreous acid in ſome degree, and by expoſure to air they both return to the ſtate of the unctuous liquid acid. The vitreous acid is a very powerful flux for all earthy and many metallic ſubſtances, and ſtrongly acts upon earthen crucibles, ſo that in fact it can hardly be obtained abſolutely pure, unleſs melted in a platina crucible. The phoſphoric and the boracic acids reſemble each other ſo ſtrongly in their unalterability in any fire, and their powerful action as a flux, that they have been thought to be the ſame ſubſtance under ſome modification; but no experiments have as yet confirmed this opinion.

This acid is not acted on by hydrogen or ſulphur, but charcoal decompoſes it entirely in a ſtrong heat, as is ſeen in the proceſſes for the preparation of phoſphorus deſcribed under that article.

The combinations of this acid with the ſeveral baſes are deſcribed in the following article.

PHOSPHATS and PHOSPHITES.

The ſalts formed by the union of the phoſphoric acid with the ſeveral baſes are called *Phoſphates*, thoſe with the phoſphoreous acid, *Phoſphites*. The former of theſe will be firſt deſcribed.

There are ſome circumſtances belonging to the phoſphates in general, which may be previouſly mentioned. They are all, except the phoſphat of ammonia, fixed in the fire, and readily run into a glaſs by a red heat. The phoſphat of ammonia loſes entirely its alkali, and when kept in fuſion for a little time pure phoſphoric acid is left.

A remarkable circumſtance in which the phoſphats differ from the ſulphats, is, that the former are not decompoſed by calcination with charcoal, which ſeems to have no effect on them. The phoſphoric acid however is compleatly decompoſed by this method, and alſo the phoſphat of ammonia, but the latter only on account of the volatilization of the alkali, which leaves the acid naked. Hence phoſphorus can be made directly only from the phoſphoric acid or phoſphat of ammonia.

With many of the baſes this acid unites in more than one proportion, forming with the ſame alkali and the ſame acid, ſalts differing extremely in ſolubility and ſenſible qualities.

Many of the other acids decompoſe the phoſphats partially or totally.

PHOSPHAT OF POTASH.

When phoſphoric acid and potaſh are in mutual ſaturation, a ſalt is produced which is uncryſtallizable, but when evaporated ſufficiently paſſes into the ſtate of a thick jelly which is deliqueſcent in the air. It is therefore extremely and almoſt indefinitely ſoluble in water; when heated it ſwells and bubbles till it has parted with its water, after which it melts into a clear colourleſs glaſs. It is decompoſed by the ſulphuric, nitric, and muriatic acids, and by lime, barytes, and ſtrontian, ſo that if a little lime-water, for example, be dropped into a ſolution of this, or any other alkaline phoſphat, a white precipitate of phoſphat of lime takes place. Its conſtituent parts are not known, nor is it uſed.

Sub-Phoſphat of Potaſh. This variety was firſt noticed by Darracq,[b] and occurred in repeating ſome experiments on the ſuppoſed decompoſition of the alkalies. On heating to vitrification a mixture of two parts of oxymuriat of potaſh with one of phoſphoric acid, and digeſting the maſs in cold water, a white inſoluble granular ſubſtance is left, which was miſtaken for phoſphat of lime, but is in reality the phoſphat of potaſh in queſtion. By evaporating the ſolution and again calcining, more of this granular ſubſtance is left behind on digeſtion with water, and thus by four or five proceſſes the whole is converted to this phoſphat.

The ſame ſalt may alſo be produced in a ſhorter way by fuſing in a platina crucible neutralized phoſphat of potaſh with an exceſs of potaſh.

This ſub-phoſphat is inſoluble in cold water, but diſſolves in a ſmall degree with a boiling heat. It is extremely fuſible and melts before the blow-pipe into a perfect bead of glaſs, which is tranſparent whilſt in fuſion, but becomes opake on cooling. The proportions of its conſtituent parts are not known.

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[a] Guerſen in Phil. Mag. vol. 17.

[b] An. Chim. tom. 40. p. 177.

Phosphat of Soda.

This ſalt is now the beſt known of the alkaline phoſphats, having been introduced in pharmacy by Dr. Pearſon as a very uſeful purgative. It may be prepared in ſeveral ways. The ſimpleſt, but by much the moſt expenſive (and therefore never uſed in quantity) is firſt to prepare phoſphoric acid by the combuſtion or oxygenation of phoſphorus, and then to add carbonat of ſoda in exceſs, to evaporate, and cryſtallize. This ſalt is however actually prepared by adding carbonat of ſoda to the phoſphoric acid (or rather the acidulous phoſphat of lime) procured by decompoſing bone-aſh by ſulphuric acid. The method of making this decompoſition has been deſcribed under the article phoſphorus, and will be further noticed when treating of *Phoſphat of Lime*.

To obtain this ſalt pure, the ſulphuric acid ſhould not be more than is ſufficient to decompoſe the bone-aſh, and the ſulphat of lime ſhould be allowed to precipitate by cooling (after concentration of the acid liquor) before the alkali is added. The acid liquor is then to be diluted with ſufficient water, and carbonat of ſoda added till there is a very ſenſible exceſs of alkali, after which the ſolution is to be evaporated conſiderably and ſet by to cryſtallize. The phoſphat of ſoda then ſeparates in large well defined cryſtals, generally rhomboidal or priſmatic.

The mother water is then to be again evaporated, adding either ſoda or phoſphoric acid, according as it is too little or too much alkaline, and a freſh crop of cryſtals is obtained.

This ſalt naturally contains and requires an exceſs of ſoda, for when merely ſaturated it will not cryſtallize.

The quantity of phoſphat of ſoda obtained in general is about equal to the carbonat of ſoda employed.

Another and perhaps a cheaper way of preparing this ſalt is given by Mr. Funcke, a German chemiſt.[c] Add to bone-aſh, diffuſed in water, juſt enough dilute ſulphuric acid to ſaturate the carbonat of lime which it always contains in ſmall proportion, which is known by the ceſſation of the effervefcence. Then diſſolve the whole in nitric acid and add to the ſolution as much ſulphat of ſoda as the quantity of bone-aſh uſed. Diſtill the whole to dryneſs, to recover the nitric acid, and the reſidue in the retort is a mixture of phoſphat of ſoda and ſulphat of lime, formed by the mutual decompoſition of the phoſphat of lime and the ſulphat of ſoda. The phoſphat of ſoda is then ſeparated by ſolution and cryſtallization in the uſual manner. It is obvious however that if too much ſulphat of ſoda be added, the exceſs muſt mix with the phoſphat of ſoda. This admixture of ſulphat of ſoda may be detected by nitrat or muriat of barytes, which forms a white precipitate with both ſalts, but the phoſphat of barytes is again decompoſed, and forms a clear ſolution with nitric or muriatic acid, whilſt the ſulphat of barytes remains untouched.

Phoſphat of ſoda has a ſimply ſaline taſte without any thing nauſeous or bitter (in which it differs from many other of the purgative ſalts) it ſhews with vegetable colours the marks of exceſs of alkali, it effloreſces in the air, but only on its ſurface.[d]

It is one of the moſt ſoluble of the non-deliqueſcent ſalts, requiring no more than four parts of cold water, and two of boiling, whence it eaſily cryſtallizes from its hot ſaturated ſolution on cooling. It is compoſed according to Thenard[e] of 66 per cent. of water of cryſtallization, 15 of phoſphoric acid, and 19 of ſoda, as determined from the following facts, namely, that 100 parts loſe 66 on calcination, and the reſidue decompoſed by muriat of lime give 33 of phoſphat of lime, of which the acid is eſtimated at 15.

When heated, this ſalt melts in its own water, bubbles and boils up, and at laſt, when red hot, it ſubſides into a glaſs which before the blow-pipe is clear when hot, but on cooling grows opake, and aſſumes nearly the form of the garnet. This ſingular property it has in common with the phoſphat of lead.[f]

The ſulphuric, nitric, and muriatic acids decompoſe it only partially, leaving in the ſolution an acidulous phoſphat of ſoda. The ſame is produced by adding phoſphoric acid, and this ſalt is extremely ſoluble, ſcarcely cryſtallizable, and takes the form of ſmall ſoft brilliant threads, like boracic acid.[g]

The phoſphat of ſoda, beſides its uſe in medicine, has been employed with ſome ſucceſs as a ſubſtitute for borax, in the ſoldering of metals.

Phosphat of Ammonia.

This combination is found in tolerable abundance in urine, but united with phoſphat of ſoda, from which it is ſcarcely poſſible to ſeparate it, and therefore to obtain it pure, it muſt be formed by the direct union of its two ingredients. For this purpoſe ſaturate the acid liquor (ariſing from the decompoſition of bone-aſh by ſulphuric acid) with pure ammonia, which will ſeparate the phoſphat and ſulphat of lime, and the clear liquor contains the pure phoſphat of ammonia, if no exceſs of ſulphuric acid has been employed. If carbonat of ammonia inſtead of pure ammonia be uſed, ſome of the phoſphat of lime remains in ſolution, which however may be got rid of by evaporating the clear liquor nearly to dryneſs, and rediſſolving in cold water. The filtered ſolution muſt then be ſuperſaturated with ammonia carbonated or pure, and gently evaporated to the cryſtallizing point.

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[c] Phil Journ. vol. 6. from Scherer's Journal.

[d] Pelletier.

[e] An. Chim. tom. 39.

[f] Pelletier.

[g] Fourcroy.

The form of this ſalt is a four-ſided priſm terminated pyramidally. When the alkali is not in exceſs it runs into ſmall indeterminate needles. The taſte is ſharp and cooling.

This ſalt diſſolves in four parts of cold water and in ſomewhat leſs of boiling, but not ſo much as to cryſtallize by ſimple cooling without further evaporation.

When heated, it melts, loſes firſt its water with a portion of its alkali, and then the reſt of the ammonia flies off, and nothing but pure phoſphoric acid is left. Hence it is that this is the only one of the phoſphats from which phoſphorus can be procured, as in fact, after it is red-hot, it is ſimply phoſphoric acid.

The ſulphuric, nitric, and muriatic acids decompoſe this ſalt entirely.

Phoſphat of ammonia is uſed conſiderably as a flux for earths and oxyds, eſpecially in experiments with the blow-pipe. It becomes in theſe caſes only a convenient mode of applying phoſphoric acid, as the alkali is totally expelled.

Phosphat of Soda and Ammonia. *Microcoſmic ſalt*, or *Fuſible ſalt of Urine.*

When any liquid containing phoſphoric acid, ſoda and ammonia (ſuch as urine is) is evaporated and its ſaline contents obtained by cryſtallization, theſe two phoſphats, or a portion of one or other of them, unite in a triple ſalt, which is the one in queſtion. It will be further noticed under the article *Urine*, whence it was at firſt obtained, but ſome of its properties may be mentioned in this place.

It ſeems to have no very uniform proportions of ingredients, for as Fourcroy obſerves, the quantity of ammonia is conſtantly diminiſhing by ſucceſſive ſolutions and cryſtallizations, and the acid to which it was united remains, rendering therefore the remaining ſalt more and more acidulous; and by long expoſure to the air the whole ammonia is loſt. This ſalt when firſt prepared has an exceſs of acid ſo as to turn ſyrup of violets green. It effloreſces in the air. Diſtilled per ſe it gives an ammoniacal water, and a little phoſphat of ammonia alſo riſes. Fourcroy eſtimates the proportions in 100 parts of this ſalt to be as follows: viz. of phoſphoric acid 32; of ſoda 24; of ammonia 19; of water 25.

Phosphat of Barytes.

When any alkaline phoſphat is dropped into a ſolution of any barytic ſalt, a heavy white powder ſubſides, which is the phoſphat of barytes. The ſame may alſo be prepared by digeſting phoſphoric acid with carbonat of barytes, or adding this acid to barytic water.

This ſalt is inſoluble in water either hot or cold, and even in phoſphoric acid. The ſulphuric, nitric, and muriatic acids decompoſe it by ſimple elective attraction.

It is fuſible at a high temperature, and when kept melted on charcoal by the blow-pipe it gives a yellow phoſphoric flame.[h]

It is not uſed.

Phosphat of Strontian.

This ſalt may be prepared like the former either by double decompoſition of the earthy muriat or nitrat, or by the direct union of the conſtituent parts. It is in the form of a white heavy powder, entirely inſoluble in water, but it differs from the former ſalt in being ſoluble in an exceſs of phoſphoric acid. Before the blow-pipe on charcoal it melts and gives a purple flame.

It is entirely decompoſed by the ſulphuric acid, but only partially by the nitric and muriatic acids, and an acidulous phoſphat of ſtrontian is left. In this it differs from the phoſphat of barytes. It is compoſed according to Vauquelin of 48.76 per cent. of ſtrontian, and 41.24 of phoſphoric acid.

Phosphat of Lime.

This is by far the moſt important of the earthy phoſphats, and is that which has been examined with the moſt attention.

It is found native both as a mineral and as a conſtituent part of a number of animal organs and fluids. The mineral phoſphat of lime is deſcribed under the article *Apatit*, of which there are ſeveral varieties in the animal kingdom. Phoſphat of lime is contained moſt copiouſly in *Bone*, as has been fully detailed under that article.

It alſo forms the aſh or earth that remains after every ſoft animal organ has undergone the utmoſt effect of fire; and it may be detected in ſolution in a great variety of animal fluids.

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[h] Vauquelin.

There are at leaſt two ſtates of phoſphat of lime which ſhould be well diſtinguiſhed. One is that in which the conſtituent parts are fully neutralized ſo as to ſhew no marks of exceſs either in acid or baſe, and in this ſtate it is a white powder, perfectly inſoluble in water, nearly infuſible, and in appearance reſembling a ſimple earth. This is the ſtate in which it exiſts in bone-aſh, of which indeed it forms by far the greateſt part, and was formerly called the *earth of bones*.

The other ſtate which has been known much later, and which has never been found native, but is only known in the laboratory, is that in which the acid is greatly in exceſs, and may be here termed *ſuper-phoſphat of lime*. It was firſt detected in the acid liquor that is produced by decompoſing bone-aſh by ſulphuric acid, is acid to the taſte, and in a red heat readily melts into a porous glaſs. It was at firſt miſtaken for pure phoſphoric acid. It is not certain however whether the proportion of phoſphoric acid in this ſpecies is conſtant, or whether it does not admit of an indefinite variety.

We ſhall firſt deſcribe the common or neutral phoſphat.

PHOSPHAT OF LIME may be obtained quite pure either by ſaturating the pure acid with marble and then evaporating; or by waſhing bone-aſh with hot water to diſſolve out any ſoluble ſalt which it may contain; then adding a little acetous or dilute muriatic acid till the efferveſcence ceaſes to engage the carbonat of lime which it contains, and again thoroughly edulcorating.

This phoſphat of lime is infuſible *per ſe* in the moſt intenſe heat, the utmoſt effect of fire being only to reduce it to a porcellanous frit. With vitreſcent mixtures it makes glaſſes of difficult fuſibility, and more or leſs opake, as deſcribed in the article *Glaſs*.

It is entirely inſoluble in water hot or cold.

All the acids, even the carbonic, act upon it without difficulty; but probably in a different manner. If ſulphuric acid is digeſted with a very ſmall quantity of phoſphat of lime a clear ſolution is effected, which contains ſulphat of lime, and the *acidulous* or *ſuper-phoſphat* of lime, and naked phoſphoric and ſulphuric acid. The latter acid therefore partially decompoſes the phoſphat; and the ſuper-phoſphat, together with the ſulphat of lime thereby produced, diſſolves in the exceſs of acid.

When the proportion of phoſphat of lime is greater, the ſame decompoſition takes place, only the greater part of the reſulting ſulphat of lime remains undiſſolved, as is the caſe in the common treatment of bone-aſh with ſulphuric acid.

It is aſſerted by Vauquelin[i] that the nitric and muriatic, and ſome other acids, act in the ſame manner on the phoſphat of lime, and partially decompoſe it. It is not eaſy however to demonſtrate this, for when phoſphat of lime is digeſted with theſe acids, the nitric for example, a clear ſolution is made, (every product being ſoluble whatever be the mutual action of theſe ſubſtances) ſo that the ſolution may either contain phoſphat of lime ſimply diſſolved undecompoſed by theſe acids, or it may conſiſt of ſuper-phoſphat of lime, nitrat of lime, and nitric acid in exceſs. On adding an alkali, pure or carbonated, to the ſolution, a white precipitate falls down, which is phoſphat of lime as before, but it is obvious that the action of the alkali may be either ſimply to precipitate the phoſphat of lime by ſuperior affinity with the nitric acid; or, firſt to ſaturate the exceſs of phoſphoric acid in the ſuper-phoſphat, and thus to bring it to the ſtate of neutral phoſphat, and then to precipitate it by engaging the acid which held it in ſolution. If a pure alkali is uſed in this caſe the whole of the phoſphat falls down; if a carbonated alkali, a part of the phoſphat remains in ſolution by the help of the carbonic acid. Hence it may be inferred, (which is the fact) that even carbonated water will diſſolve phoſphat of lime.

Phoſphat of lime is produced alſo by double decompoſition, on dropping a ſolution of any phoſphated alkali into any ſoluble calcareous ſolution that has not any great exceſs of acid. Vauquelin alſo found[k] that on boiling phoſphat of ſoda with wet and newly precipitated carbonat of lime, the ſame reſult took place, and carbonat of ſoda with phoſphat of lime were produced.

The oxalic acid added to phoſphat of lime diſſolved in any weak acid ſeparates almoſt the whole of the lime in the form of oxalat of lime, and oxalat of ammonia appears to ſeparate the whole. From analogy it is probable that ſulphat of ammonia would have the ſame effect.

The proportion of ingredients in this phoſphat as forming bone-aſh, are ſtated by Vauquelin to be 41 per cent. of phoſphoric acid and 59 of lime. But the phoſphat formed by ſaturating phoſphoric acid (ariſing from the oxygenation of phoſphorus by combuſtion and nitric acid) with marble, is ſtated by Klaproth[l] to contain only 30.5 per cent. of acid.

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[i] Fourcroy Syſtême.

[k] Journ. des Mines, No. 37. p. 25.

The uſes of phoſphat of lime are mentioned under the article *Bone*.

SUPER PHOSPHAT OF LIME, or *ACIDULOUS PHOSPHAT*.

The preparation of this ſalt from bone-aſh and ſulphuric acid has been particularly mentioned under the article *Phoſphorus*, being that acid ſubſtance which was generally miſtaken for pure phoſphoric acid till the nature of this ſalt was explained.

When diſtilled with charcoal all the exceſs of acid, which makes the difference between the neutral and the ſuper-phoſphat, is decompoſed by the charcoal and yields phoſphorus in proportion, and the neutral phoſphat remains in the retort.

The proportion of acid to lime, however, appears to vary conſiderably, for Berthollet[m] found that on waſhing with water the ſuper-phoſphat depoſited during the concentration of the ſolution from bone-aſh and ſulphuric acid, it reſolved itſelf into two portions, one of which diſſolved in the water and the other not.

This ſuper-phoſphat of lime is prepared with moſt accuracy by digeſting phoſphat of lime in phoſphoric acid till it is ſaturated. This ſolution yields the ſalt by evaporation in the form of ſmall ſhining ſcales or filaments[n] which have almoſt a gelatinous conſiſtence, and a very ſour taſte. This is the ſtate in which the phoſphat of lime is contained in freſh urine. This ſalt is ſomewhat deliqueſcent, is ſoluble in water, more in hot than cold, ſo as to cryſtallize by cooling. When heated it melts, ſwells, and finally vitrifies at a moderate red heat. The glaſs is opake till the fuſion is compleat, and it then becomes clear, ſo that opacity is not a conſtant ſign of the preſence of lime, as has been ſuppoſed. This glaſs is not in the leaſt deliqueſcent, is inſipid, and inſoluble in water, in all which circumſtances it differs from the vitreous phoſphoric acid. Charcoal decompoſes it after being vitrified, as much as before, but probably with more difficulty.

The acids probably do not act upon this ſalt except ſimply to diſſolve it. All the alkalies and earths reduce it to the ſtate of neutral phoſphat by ſaturating the exceſs of alkali, and cauſe the phoſphat to precipitate.

If a large quantity of alcohol is added to a ſolution of the ſuper-phoſphat of lime it takes up much of the exceſs of acid, without a proportional quantity of the lime; ſo that the remainder is left in a ſtate more approaching to the neutral phoſphat.

The compoſition of this ſalt when prepared by phoſphoric acid and phoſphat of lime, according to Vauquelin, is 54 per cent. of phoſphoric acid and 46 of lime, and of this quantity of acid, about 32 parts are required to ſaturate the lime in the proportions belonging to the neutral phoſphat, leaving therefore 22 parts of exceſs of acid, which alone can be decompoſed by charcoal. Hence, according to this eſtimation, 100 parts of the acidulous phoſphat will yield no more phoſphorus than can be obtained from 22 parts of pure phoſphoric acid.

PHOSPHAT OF MAGNESIA.

This ſalt may be prepared either by ſaturating phoſphoric acid with carbonat of magneſia and evaporating to the cryſtallizing point; or by double decompoſition, by adding phoſphat of ſoda to the ſulphat or any other ſalt of magneſia. When the two latter are added in a conſiderably concentrated ſolution, after ſome hours the phoſphat of magneſia depoſits in tranſparent and irregular cryſtals, and the clear liquor contains ſulphat of ſoda.

This ſalt requires 50 parts of cold water for its ſolution, but leſs of boiling water. The ſulphuric, nitric, and muriatic acids, decompoſe it entirely, as do the fixed alkalies, lime, barytes, and ſtrontian, but ammonia only partially, forming a triple ſalt.

Phoſphat of magneſia melts in a red-heat into a perfect glaſs.

It is not uſed.

It is contained naturally in urine.

PHOSPHAT OF AMMONIA AND MAGNESIA.

This triple combination was diſcovered by Fourcroy in a calculus found in a horſe's inteſtine, and ſince that time it has been detected in the bones of moſt animals in ſmall quantity. The mode of analyſis is deſcribed under the article *Bone*. It is formed directly by adding phoſphat of ammonia, or ammonia, or its carbonat to phoſphat of magneſia; and it alſo is depoſited by adding phoſphat of ſoda to any triple ammoniacal ſalt of magneſia. On this fact Dr. Wollaſton has ſuggeſted a convenient way of ſeparating and eſtimating magneſia when in ſolution, with or without other earths in any acid, which may be here mentioned.

Add to the ſolution in muriatic acid (for example) ſome ſuper-carbonat of ammonia, (made by expoſing the common carbonat to the air till it loſes its ſcent) which will ſaturate the acid and precipitate the other earths, but not the magneſia, being held diſſolved by the exceſs of carbonic acid. To the ſolution (which now contains muriat of ammonia and carbonat of magneſia,) then add a cold ſaturated ſolution of phoſphat of ſoda, and in a very ſhort time the whole will be turbid with a white powder, which ſoon ſubſides, and is the *ammoniaco-magneſian phoſphat.*

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[l] Anal. Eſſays vol. 2. p. 164.

[m] Chemical ſtatics.

[n] Vauquelin.

[o] Berthollet.

Dr. Marcet[p] eſtimates 100 grains of this ſalt dried at 100° to contain 19 of magneſia.

This triple ſalt is ſcarcely ſoluble in water, in which reſpect it differs remarkably from the ſimple phoſphat of magneſia. By heat the ammonia flies off, and it is reduced to the ſimple phoſphat.

On diſtilling it with charcoal it gives a little phoſphorus, owing to the decompoſition of that part of the phoſphoric acid which exceeds the proportion belonging to the ſimple phoſphat of magneſia in a given quantity of the ſalt.

The ſtronger acids compleatly decompoſe it, and naked phoſphoric acid is left in the ſolution. The fixed alkalies and alkaline earths alſo decompoſe it, but by expelling the ammonia and uniting to the acid, in which caſe the magneſia is left uncombined.

PHOSPHITES.

Theſe ſalts reſult from the combination of the *Phoſphoreous* acid (already deſcribed) with the ſeveral baſes, and were frequently confounded with the phoſphats, owing to the indiſcriminate uſe of the acid reſulting from the ſlow combuſtion of phoſphorus and of the fully oxygenated acid, till their characteriſtic properties were pointed out in a ſeries of experiments undertaken by Vauquelin, and publiſhed in the Journal de l'Ecole Polytechnique.[q]

The phoſphites have ſome properties in common by which they may be particularly diſtinguiſhed from the phoſphats. The moſt ſtriking of theſe is that they all yield a ſmall quantity of phoſphorus by diſtillation without addition, and when melted by the blow-pipe even on an incombuſtible ſupport, they give out a very brilliant light, owing to the exceſs of phoſphorus burning off.

Theſe ſalts alſo precipitate gold from its ſolutions in a metallic ſtate, and detonate by percuſſion when mixed with oxymuriat of potaſh.

Their taſte alſo is not ſimply ſaline like the phoſphats, but is mixed with ſomething pungent and alliaceous.

It would be ſuppoſed from analogy with the ſulphites, that the phoſphites would ſtill more rapidly than the latter ſalts, abſorb oxygen from the air ſufficient to compleat their acidification, conſidering the great eaſe with which the firſt degree of acidification takes place in the air. The contrary however takes place, for the ſolutions of the phoſphites may remain for months in full contact with the atmoſphere before this change takes place, whereas the ſame change takes place in the ſulphites in a few days in ſimilar circumſtances. This difference is ingeniouſly explained by Vauquelin on the known principle in chemical affinity, that any decompoſition is favoured by adding to the ſubſtances in action any body with which the new compound has an affinity, and of courſe the ſtronger this affinity is, the more readily will the decompoſition take place. Thus in the inſtances here mentioned, the compleat oxygenation of the *phoſphoreous* acid in the phoſphite is favoured by the affinity of the *phoſphoric* acid (when produced) with the alkaline or earthy baſis preſent, and the ſame with the *ſulphureous* and *ſulphuric* acid. But both the actual affinity of the ſulphuric acid with theſe baſes is ſtronger than that of the phoſphoric, and the difference between the affinity of the ſulphuric and the ſulphureous acids for the ſame baſes is greater than that between the phoſphoric and phoſphoreous, and it is probably from this cauſe that the compleat oxygenation of the ſulphites is ſo much quicker than that of the phoſphats.

All the phoſphites are readily changed to phoſphats, either by applying a red heat, which burns off the exceſs of phoſphorus, or by treating with nitric or muriatic acid, which compleats their acidification.

The alkaline phoſphites can only be prepared by the direct combination of the baſe with the phoſphoreous acid, and not, (like the ſulphites from the ſulphats) by deoxygenation of the phoſphats by carbonic matter.

The individual phoſphites may be briefly noticed.

Phosphite of Potash.

This ſalt eaſily cryſtallizes on cooling a hot ſaturated ſolution of it, and takes the form of a four-ſided priſm with a dihedral ſummit.

It is ſoluble in three parts of cold water and leſs of boiling. When heated to redneſs the exceſs of phoſphorus burns off, and the reſidue which is an opake glaſs, is ſomewhat alkaline.

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[p] Analyſis of Brighton Water.

[q] 4th Cahier. p. 655.

It is compoſed, according to Vauquelin, of 49.43 per cent. of potaſh; 39.47 of phoſphoreous acid; and 11 of water of cryſtallization.

PHOSPHITE OF SODA.

This ſalt is prepared like the laſt-mentioned, but chiefly by the help of evaporation. Two parts of cold water diſſolve it, and ſomewhat leſs of boiling. The ſolution gently evaporated, depoſits the ſalt generally in the form of feathery cryſtals like ſal-ammoniac.

It is compoſed of 23.68 of ſoda; 16.32 of phoſphoreous acid; and 60 of water.

PHOSPHITE OF AMMONIA.

This ſalt has a ſtrong pungent taſte, cryſtallizes in long tranſparent needles that climb the ſides of the veſſel that contains the ſolution; is ſoluble in two parts of cold water, and much leſs of boiling.

When heated before the blow-pipe on a metal ſpoon, it ſwells, boils, and in a few ſeconds gives out a great quantity of phoſphuretted hydrogen gas, which takes fire in the air, with its uſual appearance of a circular wreath of ſmoke. Diſtilled in a retort, liquid ammonia is firſt diſengaged, which is ſucceeded by ſubphoſphuretted hydrogen, which is luminous in the air, but does not inflame like the former, and finally pure phoſphoric acid is left in the retort.

This ſalt added to nitrat of mercury precipitates a white phoſphite of mercury, which turns grey in the light.

Phoſphite of ammonia is decompoſed by the fixed alkalies, and alkaline earths, which unite with the acid and diſengage ammoniacal vapours.

It is compoſed of 51 per cent. of ammonia, 26 of phoſphoreous acid, and 23 of water.

PHOSPHITE OF LIME.

Phoſphoreous acid added to lime water forms a white precipitate, which is the phoſphite of lime. This is inſoluble in water except with an exceſs of acid, in which caſe it may be obtained by evaporation in hard minute cryſtals. This ſalt is decompoſed by moſt of the mineral acids, and by thoſe vegetable ones that produce an inſoluble ſalt with lime, ſuch as the oxalic, citric, and tartareous. Phoſphite of lime is compoſed of 51 per cent. of lime; 34 of acid; and 15 of water.

PHOSPHITE OF BARYTES.

This, like the former is inſoluble in water without addition, though not abſolutely ſo, ſince when digeſted in water, lime water added to the clear liquor cauſes a cloudineſs, owing to the decompoſition of the phoſphite of barytes, and formation of phoſphite of lime. The ſolubility of phoſphite of barytes much increaſes by an exceſs of acid. This ſalt is decompoſed by oxalic acid, which forms a cryſtalline depoſit of oxalat of barytes after remaining with it for a time.

When phoſphite of barytes is heated by the blow-pipe it becomes luminous, as all the phoſphites do, but in this inſtance the light is ſo dazzling that the eye cannot ſafely bear it.

It is compoſed of 51.23 per cent. of barytes; 41.77 of phoſphoreous acid; and 7. of water.

PHOSPHITE OF MAGNESIA.

This ſalt, like the laſt, is ſcarcely ſoluble except with exceſs of acid. It is compoſed of 20 of magneſia; 44 of acid; and 36 of water. The fixed alkalies and the alkaline earths decompoſe it entirely, but ammonia only partially, and forms with the remainder a triple ſalt.

PHOSPHORUS *Cantons* }
PHOSPHORUS *Baldwins* } See PHOSPHORI.

PHOSPHORI.

In the preceding deſcription of Kunckel's phoſphorus we have mentioned that when expoſed to the air at the common temperature, it gives out a very conſiderable quantity of light without any ſenſible emiſſion of heat. Now there are many ſubſtances which, however different from common phoſphorus in other reſpects, agree with it in preſenting the above phenomenon under particular circumſtances, on which account they are all popularly claſſed together under the general term *Phoſphori*. Of theſe we ſhall now proceed to mention the principal facts that have been as yet diſcovered.

There are three leading diviſions of phoſphoreſcent ſubſtances.

The firſt comprehends thoſe which require a previous expoſure to the ſolar or other light in order to become luminous; whence they are called *Solar phoſphori.*

The ſecond includes thoſe which without any neceſſary previous expoſure to light become luminous when moderately heated; *Phoſphori from heat.*

The third includes thoſe ſubſtances, belonging to the animal and vegetable kingdoms, which emit light ſpontaneouſly at the common temperature without the neceſſity of previous expoſure to light; *Spontaneous phoſphori.*

§ 1. *Solar phoſphori.*

A caſual diſcovery by Vincenzio Caſcariolo, a ſhoe-maker of Bologna, about 1630, was the firſt circumſtance that attracted the notice of philoſophers to this curious ſubject. This man being in queſt of ſome alchemical ſecret was induced to calcine a parcel of Bolognian ſpar, (a ſubſpecies of HEAVY SPAR, or native ſulphat of barytes) which he had procured from Monte Paterno in the neighbourhood of the city; and obſerved that whenever this ſubſtance thus prepared was placed in a dark room, after having been expoſed to the ſun, it continued to emit faint rays of light for ſome hours afterwards. In conſequence of this intereſting diſcovery the Bolognian ſpar came into conſiderable demand among natural philoſophers, and the curious in general, ſo that the beſt method of preparing it became an object of even ſome pecuniary importance. The family of Zagoni were the moſt ſucceſsful in this purſuit, and in conſequence furniſhed large quantities of *Bolognian phoſphorus* to all parts of Europe till the ſubſequent diſcovery of more powerful phoſphori put an end to their monopoly. The particular proceſs employed by the Zagonis is not known, but we learn from Kircher that if the mineral is finely pulverized and then beaten up into a paſte with white of egg or linſeed oil, and calcined in the open fire, it will after expoſure for a minute to the light exhibit its phoſphoreſcent quality. Many years afterwards Marggraaf in analyſing other varieties of ſulphated barytes found that they were all capable of being made into phoſphori by forming them, when pulverized, into thin cakes with gum tragacanth or other mucilage, and then carefully calcining them at a red heat. Some management however is requiſite in conducting the calcination that it may be neither too much nor too little, by either of which faults the luminous quality is very materially injured.

In the year 1677, or nearly half a century after the diſcovery of the Bolognian phoſphorus, G. A. Baldwin, a native of Miſnia, obſerved that if nitrat of lime was evaporated to dryneſs and then formed into a compact maſs by fuſion at a red heat, it would exhibit the ſame property of imbibing and emitting light as the former only ſomewhat inferior in degree; hence this preparation obtained the name of *Baldwin's phoſphorus*.

No other diſcovery of much moment was made on this ſubject till the year 1730, when M. du Fay, ſo celebrated for his electrical reſearches, turned his attention that way. He obſerves that all earthy ſubſtances ſuſceptible of calcination either by mere fire or when aſſiſted by the previous action of nitrous acid, poſſeſſed the property of becoming more or leſs luminous when calcined and expoſed for a ſhort time to the light. Thoſe that exhibited this quality in the greateſt perfection were found to be limeſtone and many other kinds of carbonated lime, gypſum, and particularly the topaz; ſome diamonds were alſo obſerved to be luminous by ſimple expoſure to the ſun's rays without being previouſly ignited; but flint, ſand, jaſper, agate, and rock-cryſtal, were found to be incapable of becoming phoſphoreſcent.

Shortly after theſe intereſting diſcoveries of M. du Fay the ſubject was taken up by Becaria[a], who greatly enlarged the liſt of phoſphoreſcent ſubſtances and found that a vaſt variety of bodies were convertible into phoſphori by the mere light of the ſun; this he obſerved to be particularly the caſe with regard to the different varieties of carbonat and ſulphat of lime, organic animal remains, and geodes lined with minute cryſtals of quartz; moſt compound ſalts when clear and cryſtallized, particularly Glauber's ſalt, nitre, and borax, were alſo found to be phoſphorescent; of vegetable ſubſtances, all the farinaceous and oily ſeeds, all the gums and ſeveral of the reſins, the white woods, and vegetable fibre either in the form of paper or linen, alſo ſtarch, and loaf ſugar, proved to be good phoſphori after being made thoroughly dry and expoſed to the direct rays of the ſun; ſundry animal matters by a ſimilar treatment were alſo converted into good phoſphori, particularly bone either freſh or calcined, ſinew, glue, hair, horn, hoof, feathers, and ſhells of fiſh. He alſo diſcovered that this property might be communicated to rock cryſtal and ſome of the gems by rubbing them againſt each other ſo as to roughen their ſurface, and then placing them for ſome minutes in the focus of a lens by which the rays of light were concentrated upon them at the ſame time that they were alſo moderately heated.

In the year 1768, Mr. Canton[b] contributed ſome important facts relative to ſolar phoſphori, and communicated a method of preparing a very powerful one, which after the inventor is uſually called *Canton's phoſphorus*. It is thus made. Calcine oyſter ſhells in the open fire for half an hour, then ſelect the whiteſt and largeſt pieces and mix them with flowers of ſulphur in the proportion of one part of the latter to three parts of the former, pack the whole cloſely into a crucible, lute on a cover, and heat it pretty ſtrongly for one hour; when the crucible has again become quite cold turn out its contents, and ſelect the whiteſt pieces for uſe.

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[a] Act. Bologn. 1744—1747.

[b] Phil. Tranſ. lviii. p. 337.

The laſt perſon who has paid much attention to the ſubject of ſolar phoſphori is Mr. B. Wilſon, by whoſe very able experiments ſome important errors of Becaria have been rectified and to whom the diſcovery is due of the ſimpleſt and moſt powerful of all the phoſphori belonging to this claſs. *Wilſon's phoſphorus* is thus prepared. [c]Select a ſcore of oyſter ſhells, the thicker they are the better, then take moſt of the flaming coals, but not all of them, off a fire that is burning briſkly, ſtrew the ſhells over the ſurface and replace the coals that have been taken off. In about an hour's time take out the calcined ſhells obſerving to break them as little as poſſible, and after expoſing them for a few minutes to the light they will be found to have acquired a high degree of phoſphoreſcence glowing in the dark in a very beautiful manner, with moſt of the priſmatic colours. It is not however abſolutely neceſſary that the ſhells ſhould be calcined in the open fire, for if they are heated ſufficiently in a cloſe crucible they will exhibit priſmatic colours, chiefly blue and green, though not ſo bright as by the former method. If the calcination is effected in an iron crucible, all thoſe parts of the ſhells that are in contact with the ſides of the crucible will glow with a red light. The contact of inflammable matter, and particularly charcoal, with the ſhells during their calcination appears eminently to contribute to the brilliancy of the phoſphorus; hence it is that if the ſhells are calcined in a crucible in contact with thin plates of ſteel, the phoſphorus thus produced will be much more bright and of more various colours than where plates of iron are employed; and on the other hand if flat pieces of charcoal are made uſe of, the intenſity of the colours, eſpecially the blue, green, and red, is far greater than in thoſe produced by the ſteel.

In conducting experiments on ſolar phoſphori, as the light from many of them is very evaneſcent, ſome contrivance is neceſſary that they may be preſented to the eye immediately on their removal into the dark, all other light being at the ſame time carefully excluded. For this purpoſe it is convenient to have a ſmall cloſet painted black on the inſide, and with a black curtain hung up before the door; the window of the cloſet ſhould be accurately cloſed with a wooden ſhutter lined with black cloth and a thick curtain of the ſame colour. In the ſhutter ſhould be a ſmall ſlider through which a perſon within the cloſet may expoſe any ſubſtance to the light, at the ſame time that the interpoſed curtain prevents any external rays from reaching the eyes of the experimenter, by which even the weakeſt degree of phoſphoreſcence will ſcarcely eſcape his obſervation. Laſtly, to provide for a due ſupply of freſh air, two pieces of curved pipe made of any opake material ſhould be fixed in the door, the one at the top and the other near the bottom. In a room thus conſtructed the following appearances may be perceived.

Any of the phoſphori mentioned above, after expoſure to the light for half a minute or leſs, being introduced into the cloſet, will be obſerved to emit light for a longer or ſhorter time, becoming by degrees more and more dim till their luminouſneſs entirely ceaſes. To produce this quality in ſome the direct rays of the ſun are neceſſary, but in others, particularly the calcareous and barytic phoſphori, the common light of day is quite ſufficient; in all however the light is greater when the weather is dry and warm, than when it is cold and wet. The colour of the light in moſt caſes is white or reddiſh white, but in Wilſon's phoſphorus not only white but all the priſmatic colours make their appearance, ſometimes being all united in a ſingle ſpecimen, at other times each piece exhibiting only one or two colours. In every ſpecies of ſolar phoſphorus the light after having been extinguiſhed may be renewed for any number of times without the ſmalleſt apparent diminution of brilliancy by ſimple re-expoſure for a few ſeconds to the light.

If while the phoſphorus is preſented to the light it is moderately heated, its luminouſneſs will by this means be very ſenſibly augmented. Thus if a common box ſmoothing iron heated in the uſual manner be placed for half a minute on a ſheet of dry white paper, and the paper be then expoſed to the light, and afterwards examined in the dark cloſet, it will be found that the whole paper will be luminous, that part however on which the iron had ſtood being much more ſhining than the reſt.

The effects of a variation in temperature on phoſphori *after* having been expoſed to the light are alſo very remarkable. If a thin glaſs tube be filled with Canton's or Wilſon's phoſphorus, and, as ſoon as it is brought into the dark cloſet, be plunged half way into a freezing mixture for a few minutes, it will be found on again withdrawing the tube that the cold portion is much leſs luminous than the other, and if the freezing mixture has been ſufficiently powerful, it will be entirely extinguiſhed. This however is by no means an exhauſtion but only a ſuſpenſion of the luminous property, for as the dark part of the tube begins to acquire the temperature of the ſurrounding air its light will return, and it will continue to ſhine longer than the other part of the tube in proportion to the time that it was kept in the freezing mixture. Hence it may be inferred, that at a very low temperature the preſent claſs of ſolar phoſphori would ceaſe to exiſt.

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[c] Wilſon on Phoſphori, p. 20.

As cold retards ſo heat quickens the emiſſion of light from phoſphoric ſubſtances. Thus if the tube mentioned in the laſt paragraph, be dipped half way into boiling water, a great increaſe of brightneſs will be perceived in the immerſed portion, which in a minute or leſs will be ſucceeded by entire darkneſs, while the part not heated will ſhine much longer, though with leſs ſplendor.

If any of theſe phoſphori after having been kept in the dark till it is totally extinguiſhed, be placed (without any further expoſure to the light) in the warm hand, its luminouſneſs will be for a ſhort time renewed; if after the warmth of the hand has ceaſed to produce any effect, it be placed in boiling water, a further emiſſion of light will take place, and finally it may be entirely exhauſted of its light by being placed on a metallic plate, heated nearly to redneſs. Hence it appears that there are two cauſes of the extraordinary brightneſs exhibited by ſolar phoſphorus when ſtrongly heated immediately on being introduced into the dark room; in the firſt place there is a greater quantity of light actually given out, and, ſecondly, the whole is diſcharged in perhaps a twentieth of the time in which even a part would be exhauſted at the common temperature.

With regard to the origin of the light in theſe ſubſtances there are two theories. According to the one it is ſimply the ſolar light which has been previouſly imbibed by them; and according to the other it is the inherent light of the phoſphoric ſubſtance itſelf. In favour of the firſt hypotheſis it may be obſerved that the phoſphoreſcence cannot take place without previous expoſure to the light, and that the period of its greateſt brilliance is the moment of its being placed in the dark, whence it regularly and rapidly diminiſhes till it is totally extinguiſhed. But the ſtrongeſt proof of the truth of this theory is an experiment related by Becaria, in which he affirms, that thoſe phoſphori which under the uſual circumſtances emit a white light, give out coloured rays in the dark, correſponding to thoſe which they receive from the ſun, with the interpoſition of a plate of coloured glaſs. Many doubts however have ariſen as to the accuracy of the fact here mentioned. Du Fay's experiments made before thoſe of Becaria, lead to a directly oppoſite reſult, the light emitted by the phoſphorus being of the ſame tint whatever was the colour of the glaſs through which the rays paſſed to the phoſphorus. In like manner M. Bourriot on repeating the experiments of Becaria, entirely failed in producing the effects ſaid by the latter to have taken place; nor was M. Magellan more ſucceſsful. Mr. Wilſon has examined this part of the ſubject conſiderably at length, with the following reſults.[a] A piece of prepared oyſter ſhell which by expoſure to the common light gave out a white light was at different times placed in the ſolar rays with the interpoſition of a plate of red glaſs, and after a few ſeconds was haſtily tranſferred into the dark cloſet, but though the experiment was repeated ſeveral times, not the ſmalleſt approach towards a red colour was perceived in the light of the phoſphorus. The ſame phoſphorus was now expoſed to the different coloured rays of the priſmatic ſpectrum, but whatever was the colour of the ray in which it was placed, the ſame tint of white light was viſible in every experiment.

Another piece of phoſphorus diſpoſed to ſhine with a red light was now ſelected and expoſed, firſt to the common light and afterwards in ſucceſſion to the different refracted rays as ſeparated by the priſm, when it was found that the phoſphoric light was much intenſe when excited by white light, and by far the leaſt when excited by red light; the violet rays excited a degree of red light full ten times as great as the red rays did. Another ſingular circumſtance was, that if the red priſmatic rays were thrown upon the phoſphorus already made luminous by the violet rays the immediate effect was a remarkable deterioration in the tone of the colour, ſo that it was ſcarcely more brilliant than when excited by the red rays. In like manner the red and yellow priſmatic rays were found to excite the phoſphoreſcence in a piece of ſhell diſpoſed to emit blue light, with much more energy than the blue or violet rays themſelves.

Theſe ſingular facts appear ſcarcely reconcilable to the hypotheſis of the phoſphoreſcent light being merely that which has been previouſly imbibed from the ſun, yet on the other hand they by no means prove that it is properly inherent in the phoſphoric ſubſtance itſelf.

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[a] Wilſon on Phoſphorus, p 97.

The ſolar phoſphori are not only capable of being excited by the rays of the ſun but by any other light that is ſufficiently powerful, and thoſe phoſphoreſcent ſubſtances which ſhine with the greateſt brilliance by expoſure to the light of day, are, as might naturally be expected, moſt eaſily excited by other luminous bodies. The rays of the moon even when concentrated in a lens appear to be incapable of illuminating even the moſt ſenſible kinds of phoſphori. The light of a bright candle, or the momentary flaſh from the exploſion of a little gunpowder, or from an electrical diſcharge, are ſufficient to render Wilſon's phoſphorus, when well prepared, very viſibly luminous.

It is not very certainly known what is the effect of the different gaſſes on the luminous property of theſe bodies. According to ſome obſervers, a piece of calcareous phoſphorus, when placed in the receiver of an air-pump, becomes rapidly leſs luminous as the air is exhauſted, but according to others the rate at which the light fades is not more rapid than uſual. We have the reſpectable authority of Mr. Canton, for ſtating that his phoſphorus incloſed in a glaſs flaſk, and hermetically ſealed, retains its property of becoming luminous for at leaſt four years, without any apparent decreaſe of activity.

§. 2. *Phoſphori from heat.*

Beſides thoſe ſubſtances that are phoſphoreſcent by expoſure to the rays of the ſun, there are others which give out light when ſimply heated. Theſe materially differ from the former in this circumſtance, that after having been continued at any particular temperature till their luminouſneſs is exhauſted, they are incapable of becoming again luminous, except at a greater heat than that to which they were firſt ſubjected. The range of temperature at which theſe bodies become luminous is not very extenſive, commencing at about 400° Fahr. and terminating at the loweſt viſible red heat. In ſome of theſe phoſphori the light is almoſt momentary, but in others it endures many minutes. The intenſity of the light appears to undergo no ſort of alteration whether the body that emits it is in a Torricellian vacuum, or plunged in any of the natural or artificial gaſſes. The following is a liſt of the ſubſtances exhibiting this property, arranged by Mr. T. Wedgewood according to the brilliancy of their light.[e]

That variety of the blue fluor of Derbyſhire which when ſcraped or ſtruck emits a fetid bituminous odour, is the moſt phoſphoreſcent by heat of all the known ſubſtances; it glows when moderately heated with a pale emerald green light ſufficiently intenſe to be very viſible even in day light. To the ſecond rank belong the common Swineſtone, the common blue fluor, and red felſpar, all theſe as well as the following exhibit a white or reddiſh light. The third claſs includes the diamond, the ruby, carbonated barytes, chalk, colourleſs calcareous ſpar, ſea ſhells, granite, and white fluor. The fourth claſs comprehends white ſand, carbonated magneſia, heavy ſpar, flint, white marble, quartz, porcelain and earthen-ware. The fifth claſs includes moſt of the metals, ſulphat of potaſh, borax, white paper, white linen, ſawduſt and aſbeſtos. Under the ſixth and laſt claſs are comprehended oil, wax, ſpermaceti and butter when boiling or nearly ſo. To exhibit the luminous property of theſe bodies in the greateſt perfection, the harder ones ſhould be reduced to a very coarſe powder and ſprinkled in a dark room on the ſurface of a thick metallic plate heated below redneſs. A very ſtriking exhibition of the phoſphoreſcence of the fetid blue fluor may be made by heating ſome oil in a clear flaſk till it becomes luminous, and then dropping in about a teaſpoonful of pulverized fluor: the inſtant this latter comes in contact with the hot liquid a bright flaſh of green light is given out, which may be renewed for many times by repeatedly ſhaking the veſſel.

Moſt of the above mentioned ſubſtances are phoſphoreſcent alſo by friction, which is aſcribed by Mr. Wedgewood to the heat produced on this occaſion; in ſome inſtances it may, yet as there are certain bodies, ſuch as Tremolite and a particular variety of blende, which give out much light even from the ſcratch of a pin, the luminouſneſs in theſe caſes can hardly have been excited by the reaction of the trifling quantity of heat thus produced. Mr. Davy has alſo obſerved that if fluor be heated till it ceaſed to become luminous, it is ſtill capable of producing light by colliſion.

§. 3. *Spontaneous Phoſphori.*

In this ſection we mean to include certain animal and vegetable ſubſtances which at a particular period of their ſpontaneous decompoſition become luminous. In animal ſubſtances this phoſphoreſcence makes its appearance before the commencement of putrefaction, and ceaſes when the latter is compleatly eſtabliſhed. The fleſh of birds has we believe never exhibited this phenomenon, and that of quadrupeds but rarely. Several ſpecies of inſects are luminous, as the common glow worm, the fire flies of America, and the fulgora of China; alſo a kind of crab, (the cancer fulgens) a few ſhell fiſh, and ſome of the marine molluſcæ: theſe however are luminous not merely during the period juſt mentioned, but alſo when alive. The fleſh of a few freſh water fiſh eſpecially the carp, and of the tadpole, but not of the frog, becomes luminous before putrefaction. But the fleſh of ſalt water fiſh more than all other ſubſtances is peculiarly rich in phoſphoreſcent matter, and accordingly has been the principal ſubſtance on which the following experiments have been made. Of vegetable matters that become luminous the principal is decayed wood; peat alſo, though very rarely, haſe exhibited a ſimilar appearance. The chief obſervers who have turned their attention to this ſubject are Boyle, Canton,[f] and Dr. Hulme.[g]

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[e] Phil. Tranſ. vol. lxxxii. p. 28

The only laboratory required for theſe proceſſes is a dark room, and the only preparation of the fiſh is that they ſhould be gutted and ſplit, and their ſcales taken off. The herring ſeems to afford more light than other fiſh.

The time which ſea fiſh, as freſh as they can commonly be procured in a market, take to become luminous is about 12 hours or leſs: the phoſphoreſcence is faint and partial at firſt, but ſoon ſpreads over the whole ſurface, and becomes very bright before any putrefaction comes on; in proportion as this latter ſtate is eſtabliſhed the light becomes more faint, but does not entirely diſappear in leſs than four or five days: the luminous matter may be ſcraped off with a blunt knife, and will continue to ſhine for a conſiderable time. But though the emiſſion of light diminiſhes as putrefaction increaſes, there appears no neceſſary connexion between the two proceſſes, for if a piece of herring is put into a brine conſiſting of 1 part by weight common ſalt and 8 parts water, it will be found in about 24 hours that the liquor when agitated is ſlightly luminous, and during the two ſucceding days its brilliancy will increaſe; then declining, it will become wholly extinct in three or four days more, and at the end of this period both the fleſh and brine will be entirely free from any putrid ſmell. The ſulphats of ſoda or magneſia employed in the ſame proportions as common ſalt will produce ſimilar effects, only the phoſphoreſcence will not continue ſo long.

The phoſphoreſcence is deſtroyed by immerſion in pure water, in lime-water, carbonated water, and liquid ſulphuretted hydrogen, alſo by fermented liquors, by alcohol, by the mineral and vegetable acids, and by the alkalies, alſo by *ſaturated* ſolutions of thoſe neutral ſalts which when moderately diluted contribute moſt eminently to its preſervation. Hence if ſome of the luminous matter be ſcraped from the ſurface of the fiſh, and well ſhaken in a dilute ſolution of common ſalt, Glauber's ſalt, &c. the whole will appear richly luminous, but by then adding a ſufficiency of dry ſalt to ſaturate the ſolution, the light will be extinguiſhed: in this caſe it is however only latent, for by pouring in pure water enough to reduce the ſtrength of the ſaline ſolution, the light reappears as before, a ſubſequent doſe of ſalt will again extinguiſh it, and more water will reſtore its luminouſneſs.

The production of this phoſphoric light does not afford any heat aſcertainable by the thermometer. By expoſure to a freezing temperature the light is rendered latent, but it is wholly deſtroyed when plunged into boiling water; a conſiderable warmth however obviouſly increaſes its brilliancy.

It appears that this light cannot be produced except by the contact of atmoſpheric air, yet when once excited it is not increaſed by being placed in oxygen gas, or impaired by azot. When put into the receiver of an air-pump it becomes faint, and is at length extinguiſhed as the exhauſtion of the veſſel proceeds; the readmiſſion of air reſtores its former brightneſs. Nitrous gas, carbonic acid, hydrogen, and ſulphuretted hydrogen totally and inſtantaneouſly extinguiſh it.

The light of dead glow-worms, and of rotten wood follows nearly the ſame rule with regard to the action of temperature and the gaſſes as fiſh light does, but it ſeems to be little affected by pure water and various ſaline ſolutions which have ſo ſtriking an action on the latter.

PHOSPHURET
PHOSPHURETTED HYDROGEN } See Phosphorus (*Kunckel's.*)

PIERRE PONCE. See Pumice.

PISOLITE. See Limestone.

PITCH. See Turpentine.

PITCH, JEW's. See Bitumen.

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[f] Phil. Trans. lix. p. 446.

[g] Ditto, xc. p. 161. xci. p. 403.

PITCHSTONE. *Pierre de Poix*, Fr. *Pechſtein*, Germ.

The colour of this mineral is very various, being grey and green of various ſhades, alſo honey yellow, liver brown, blood and brick red. The colours are generally pale, and not unfrequently arranged in bands. It occurs in maſs. Internally it is uſually ſhining, with rather a faint greaſy luſtre. Its fracture is imperfectly conchoidal, paſſing into ſplintery, and in proportion as it does ſo its luſtre is fainter, and it approaches to hornſtone. Its fragments are indeterminately angular, ſharp-edged. Sometimes it occurs in ſmooth granular diſtinct concretions. It is uſually tranſlucent only at the edges, the black varieties are opake. It is conſiderably hard, brittle, and eaſily frangible. Sp. gr. 2.3.

It is fuſible before the blow-pipe into a white, ſomewhat porous enamel. According to Wiegleb, the pitchſtone of Meiſſen in Saxony is compoſed of

64.58	Silex
15.41	Alumine
5.	Oxyd of Iron
84.99	
15.01	loſs

Pitchſtone occurs in mountain maſſes, and even conſtitutes entire mountains, and it forms the baſe of a particular kind of porphyry.

It abounds in Saxony, Hungary, Siberia, and other mountainous diſtricts.

It is not unfrequently confounded with hornſtone, and ſemi-opal.

PLASMA. Wern.

The colour of this mineral is green of various ſhades mixed with brown, and the whole arranged in dots, clouds and bands. It occurs in maſs, and in angular and rounded fragments incloſed in talc or ſteatite. It has a feeble greaſy luſtre both internally and externally. Its fracture is conchoidal paſſing to fine ſplintery. Its fragments are indeterminate and ſharp-edged. It is tranſlucent, and in thin pieces ſemitranſparent. Its hardneſs is nearly equal to that of Chalcedony; it is brittle, and eaſily frangible.

Its proper geological ſituation has not as yet been aſcertained; neither has it been ſubmitted to chemical analyſis. It is not uncommon in Italy and the Levant: it occurs near Bojanovitz, in Moravia, imbedded in ſerpentine, and near Toeltſva in Upper Hungary, in rounded pieces with hornſtone. Sometimes it combines with heliotrope and chalcedony, forming agate.

PLATINA. *Le Platine*, Fr. *Der Platin*, Germ. *Aurum album*, Waller.

§ 1. *Ores.*

This metal has hitherto been found only in one ſtate in which according to moſt mineralogiſts and chemiſts it is conſidered as native, though Prouſt is inclined to conſider it as in the ſtate of ſulphuret. From this latter opinion we ſhall take the liberty to diſſent, and ſhall accordingly deſcribe this ſubſtance as

NATIVE PLATINA.

The colour of this mineral is between ſilver white and ſteel grey. It comes to Europe only in the form of flat and more or leſs rounded grains, from the ſize of a pea, which is rare, to that of fine ſand. The ſurface of the grains is moderately ſmooth, and they poſſeſs rather a low degree of metallic luſtre: by friction this brightneſs approaches to that of poliſhed iron: its hardneſs is greater than that of copper: it is conſiderably ductile, and very flexible when in thin plates. Its ſp. gr. is variable, but is ſeldom leſs than 16.5, or greater than 17.2.

It is infuſible before the blow-pipe, and is inſoluble in acids, except the oxymuriatic or nitromuriatic; from its ſolution in this latter it is precipitable by muriat of ammonia, but not by green vitriol.

Nothing is as yet known of the geological ſituation of this ſubſtance except that it accompanies gold. It is found in the Rio del Pinto, and near Choco in the Viceroyalty of Peru, and near Carthagena in New Granada.

A variety of the above in ſmaller grains and of a darker colour, is alſo met with.

Platina was firſt brought into Europe in 1749, by Mr. Chas. Wood, aſſay-maſter of Jamaica, and in the ſucceeding year, ſpecimens were preſented by Dr. Brownrigg, to the Royal Society. Theſe came from Carthagena, from which place alſo were diſperſed through the Spaniſh Weſt Indies, various toys and trinkets conſiſting of this metal alloyed with ſome other, probably ſilver, as the price of the alloy was nearly equal to that of this latter metal.

Mr. Wood and Lewis began the inveſtigation of the properties of this new ſubſtance in the very year in which it was imported: it then employed the abilities of Schaeffer, Marggraaf, Bergman, Macquer, and Beaumé; and more recently of Deliſle, Morveau, Jeanety, Vauquelin and Fourcroy, Deſcotils, Muſſin Puſchkin, Prouſt, Tennant, Chenevix and Wollaſton. Many difficulties however yet remain to be overcome before the chemical hiſtory of this ſubſtance can be compleated.

§ 2. *Analyſis of the Ore.*

As all the platina which comes to Europe has previouſly undergone the proceſs of amalgamation in S. America, it generally happens that a ſmall variable quantity of mercury remains in it, ſometimes in very ſmall diſtinct globules, but more generally combined with gold into an amalgam. The eaſieſt way of ſeparating the mercury is to drive it off by heat, either in an open ladle or in an earthen retort, according as this ſubſtance is or is not to be retained. When the mercury is thus got rid of, the remaining platina has generally a much yellower caſt than before, on account of the particles of gold diſperſed through it having now acquired their characteriſtic colour. The ore is now to be ſpread thin on a ſmooth table, and by the dextrous application of a common pair of bellows, the lighter particles may be ſeparated with very conſiderable accuracy from the heavier ones. The former conſiſt of very minute cryſtals and fragments of quartz, and of two kinds of iron ore in fragments and in ſmall octohedrons: of which ſome are compleatly attractible by the magnet, (being the magnetic iron ſand) while the others are not in the leaſt ſo, and give out when roaſted, a ſlight ſulphureous odour.

The heavier particles are now to be treated with a ſmall quantity of a ſomewhat diluted nitromuriatic acid, by which the whole of the gold will be taken up, with ſome iron and a very ſmall proportion of platina and the other ingredients. From this ſolution the gold may be thrown down by means of green ſulphat of iron, and purified by ſubſequent fuſion with a mixture of nitre and borax. The proportion of gold contained in crude platina is generally pretty conſiderable, ſo as to render it well worth the labour of the chemiſt to ſeparate it if he is poſſeſſed of a conſiderable quantity. From one parcel conſiſting of 100 ounces, Prouſt[a] obtained 7 oz. of gold, and from another like quantity he procured no leſs than 13 oz. The whiteſt platina is the richeſt in gold, the black varieties containing little or none of it.

After the ſeparation of the gold, the platina is to be digeſted in nitromuriatic acid, by which it will be diſſolved, with the exception of a black matter, which was at firſt taken for plumbago, but which, from Mr. Tennant's recent analyſis appears to be a compound of two new metallic bodies, that have obtained the names of oſmium and iridium. By the addition of muriat of ammonia to the nitro-muriatic ſolution, the greateſt part of the platina is thrown down in the form of a yellow powder, which is a nearly inſoluble ammoniaco-muriat of platina. The ſolution is now to be treated with zinc, by which all its metallic contents except the iron, will be precipitated, and this precipitate when waſhed is to be digeſted in very dilute nitric acid: by this menſtruum the copper and lead uſually contained in crude platina will be got rid of, and the remainder is to be diſſolved in nitro-muriatic acid. To this latter ſolution common ſalt is to be added, and the whole evaporated to dryneſs. This reſidual ſalt contains the ſoda-muriats of platina, palladium, and rhodium, of which the latter alone is inſoluble in alcohol, and may therefore be ſeparated from the former by means of this fluid. The alcoholic ſolution now contains platina and palladium, from which nearly the whole of the former is to be ſeparated by ſal ammoniac. The ſolution being now diluted, the addition of pruſſiat of potaſh will throw down the palladium in the form of a deep orange precipitate, and from the remaining liquor when concentrated, the platina may be precipitated by muriat of ammonia.

§ 3. *Methods of working Platina.*

The great infuſibility of platina, added to the ſtrong reſiſtance which it oppoſes to common menſtrua, long excited the attention of chemiſts and artiſts, and has given birth to various ingenious proceſſes for condenſing this refractory metal into malleable maſſes, and forming of it crucibles and other inſtruments of material ſervice to the accuracy and ſimplicity of chemical analyſis. If the largeſt and whiteſt grains are carefully ſelected from a parcel of crude platina, it will be found that theſe are conſiderably malleable even when cold, and ſtill more ſo when hot: alſo if two grains are laid in contact with each other and then brought to the higheſt poſſible white heat, they may be made to adhere more or leſs perfectly by a ſtroke with a hammer, and in this way, by great patience and great dexterity, it may be practicable to form a few grains into a maſs. This however is by much too imperfect and tedious a method to be employed with any practical advantage.

It was early diſcovered that arſenic combined very readily with platina, forming an alloy of eaſy fuſibility, and from the volatility of the former of theſe metals, eſpecially when in contact with charcoal, it was expected that by proper management nearly the whole of it might be driven off, leaving the platina behind in a maſs, and poſſeſſed of its characteriſtic properties. Willis, Marggraaf, Achard and others ſucceeded to a certain degree, and faſhioned of this alloy crucibles and other chemical utenſils, leſs fuſible than ſilver, and capable of reſiſting many of the common menſtrua. M. Jeanety of Paris, a working ſilverſmith, then turned his attention to the ſame object, and after long practice and many failures, diſcovered by far the beſt method of preparing and working this alloy. The proceſs of this artiſt as reported by Berthollet and Pelletier, is the following:[b]

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[a] Ann. Chim. xxxviii, p. 148.

Having firſt ground the crude platina in water, and waſhed it over in order to ſeparate the earthy matters with which it is mixed; take three half pounds of the metal, three pounds of white arſenic, and one pound of pearlaſh: mix the whole well together, and then place in a furnace of any convenient conſtruction, a crucible capable of holding 20 lbs. of the above mixture. As ſoon as the crucible is thoroughly red hot, pour in one third of the mixture, and keep ſtirring it with a rod of platina till it comes into a ſtate of quiet fuſion; Then add another third, carefully ſtirring it as before, and after a while add the remaining third, and give the whole a good heat, ſo as to render it very fluid. Then withdraw the crucible, and after it has cooled, gradually break it up: there will be found a well formed metallic button, covered by blackiſh brown ſcoriæ, which acts pretty powerfully on the magnetic needle. This button being broken to pieces, (which is readily done on account of its great brittleneſs,) is to be again fuſed with white arſenic and pearlaſh as before, and the metallic maſs reſulting from this ſecond fuſion is generally incapable of acting on the magnetic needle: if however, this ſhould not be the caſe, a third fuſion with arſenic and alkali muſt be had recourſe to.

The firſt ſtep of the proceſs being thus finiſhed, a flat bottomed cylindrical crucible, about 3½ inches in diameter is to be made thoroughly hot in a furnace, and is then to be charged with three half pounds of the arſenicated platina mixed with an equal weight of white arſenic, and half a pound of potaſh: when theſe are well mingled and entirely fluid, the crucible is to be removed from the fire, and placed to cool in a horizontal poſition, in order that the cake of metal may be of an uniform thickneſs. The crucible when cold is to be carefully broken, and having removed the ſcoriæ, there will be obtained a cake of metal well formed and ſonorous, weighing about three ounces more than the arſenicated platina employed, and now quite ſaturated with arſenic: there is no danger of incorporating too much of this latter ingredient, it being conſtantly obſerved that the compleatneſs and rapidity of the ſubſequent purification is exactly in proportion to the quantity of arſenic which it has previouſly been made to imbibe.

The metallic maſs thus procured is to be placed in a muffle, and the heat is to be gradually increaſed till the arſenic begins to evaporate; the temperature muſt then be kept up as nearly as poſſible the ſame for ſix hours, obſerving eſpecially not to increaſe it leſt the cake melt. At the end of this period the cake will have become conſiderably porous, and is now to be withdrawn and extinguiſhed in common oil; it is then to be returned to the muffle, by which a further quantity of arſenic will be evaporated, and this alternate application of oil and heating, is to be continued till no more arſenic makes its appearance. The fuſibility of the maſs diminiſhes as the arſenic is got rid of, ſo that a much higher temperature may be employed in the latter than in the former part of this proceſs. Having carefully burnt off at a high heat all the charcoal produced by the decompoſition of the oil, the ſpungy cake of metal is to be digeſted in nitrous acid, and then edulcorated by repeated boiling in water. Three or more of the cakes are then to be put into a cylindrical crucible, and heated to the higheſt poſſible degree in a powerful furnace: while they are thus rendered ſoft, an iron peſtle let down upon them will make them cohere: they are then to be withdrawn from the crucible, heated to the utmoſt in a ſmith's fire, and carefully forged like iron on the anvil into compact bars.

The advantage of this proceſs of M. Jeanety is its cheapneſs, not requiring the platina to be previouſly diſſolved in nitro-muriatic acid; but on the other hand, the metal, though approaching a ſtate of purity, is by no means abſolutely pure: it contains a ſmall quantity of arſenic and iron, together with, probably the whole of the lead and copper that may have been caſually mingled with the ore, as well as the palladium, oſmium, iridium and rhodium, and in conſequence of this mixture is by no means capable of ſuſtaining the action of alkalies and a high heat with ſo little injury as when more accurately purified.

[b] An. Chim. xiv. p. 29.

The next method which we ſhall mention of purifying this metal was diſcovered by Count Mouſſin Pouſchkin.[c] It is effected in the following manner. Diſſolve the crude platina in nitro-muriatic acid, and throw down the platina by muriat of ammonia, and waſh the precipitate in a little cold water. Then heat the yellow powder in a crucible till it is decompoſed, and the platina becomes ſpungy and returns to the metallic ſtate: now waſh the maſs with hot water, and boil it in very dilute muriatic acid, to diſſolve out any iron that may be caſually mixed with it; then edulcorate and dry the reſidue. Of this reſidue take a few drams with twice its weight of pure mercury, and triturate the mixture in a ſtone mortar till an amalgam is produced, which may be effected without difficulty, after which by the alternate addition of mercury and platina ſeveral pounds weight of ingredients may be amalgamated in the courſe of a few hours. This amalgam when firſt made is ſoft, but in an hour or a little more acquires a conſiderable hardneſs; while yet ſoft therefore it ſhould be cloſely rammed into a tube of wood of convenient ſize, and after it has become hard, the tube with its contents may be placed in a muffle, and by the time that the wooden covering is conſumed, a great part of the mercury will be volatilized, ſo as to prevent all riſk of the bar of platina breaking when deprived of the ſupport of its wooden caſe. The metal is now to be cautiouſly heated till all the mercury is driven off, after which it is to be forged in the uſual way at the higheſt poſſible heat.

A ſtill more ſimple and equally effectual manner of working this metal has been publiſhed by Mr. Knight.[d] The platina being diſſolved in nitro-muriatic acid and precipitated by muriat of ammonia, the yellow powder hence reſulting after being edulcorated by waſhing in cold water is to be thus managed. "A ſtrong hollow inverted cone of crucible earth being procured, with a correſponding ſtopper to fit it, made of the ſame materials, the point of the latter is cut off about three fourths of the diſtance from the point to the baſe. The platina in the ſtate of a light yellow powder is preſſed tight into the cone, and a cover being fixed ſlightly on, it is placed in an air furnace and the fire raiſed gradually to a ſtrong white heat. In the mean time the conical ſtopper fixed in a pair of iron tongs ſuitable for the purpoſe, is brought to a red or a bright red heat. The cover being then removed from the cone, the tongs with the heated ſtopper is introduced through a hole in the cover of the furnace, and preſſed at firſt gently on the platina, at this time in a ſtate nearly as ſoft as dough, till it at length acquires a more ſolid conſiſtence. It is then repeatedly ſtruck with the ſtopper as forcibly as the nature of the materials will admit, till it appears to receive no further impreſſion. The cone is then removed from the furnace, and being ſtruck lightly with a hammer the platina falls out in a metallic button, from which ſtate it may be drawn by repeatedly heating and gently hammering, into a bar."

The laſt method that we ſhall notice and one that has been attended with compleat ſucceſs, was invented by Mr. T. Cock, through whoſe liberality we are enabled to communicate it to our readers.[e]

The platina being diſſolved in nitro-muriatic acid, the liquor is to be filtered through clean white ſand, in order to ſeparate the black powder which floats among it. The clear ſolution being then decompoſed by ſal-ammoniac the yellow precipitate is to be collected, moderately well waſhed in warm water and dried. It is then to be diſtributed into ſaucers which are placed in a ſmall oven conſtructed for the purpoſe, where they are expoſed for a ſhort time to a low red heat in order to bring the platina to the metallic ſtate, and to drive off by ſublimation the greater part of the muriated ammonia. When withdrawn it is a ſpungy maſs of a grey colour. About half an ounce of the platina in this ſtate is to be put into a ſtrong iron mould about 2½ inches long by 1½ wide, and is to be compreſſed as forcibly as poſſible by ſtriking with a mallet upon a wooden peſtle cut ſo as accurately to fit the mould; another half ounce is then added and treated in the ſame manner, and ſo on till ſix ounces have been forced into the mould: a looſe iron cover juſt capable of ſliding down the mould is then laid upon the platina, and by means of a ſtrong ſcrew preſs, almoſt every particle of air is forced out from among the platina. This is a part of the proceſs that requires eſpecial care, for if any material quantity of air is left in the maſs, the bar into which it is formed is very apt in the ſubſequent operations to ſcale and be full of flaws. The preſſure being duly made, the mould is to be taken to pieces, and the platina will be found in the form of a denſe compact parallelopiped. It is now to be placed in a charcoal forge fire, and heated to the moſt

[c] Nich. Journ. ix.

[d] Tilloch Phil. Mag. vi. p. 3.

[e] Original communication.

intenſe white heat in order compleatly to drive off the remaining ammoniacal muriat; this being done it is to be quickly placed on a clear bright anvil and gently hammered in every direction by a clean hammer. This is to be repeated ſeveral times, at the end of which the maſs will be perfectly compact, and fit to be laminated or wrought in any other manner that the artiſt chuſes. It is to be obſerved that while the platina is heating it muſt lie looſe in the fire, for if it were held by the tongs they would infallibly become welded to the platina, and thus greatly damage it. By the time that the platina is thus drawn down to a compact bar it will be covered by a ſomewhat reddiſh ſemivitreous cruſt proceeding chiefly from particles of the aſhes melted down upon it and extended over its ſurface by the hammer. To remove this, the bar being made red hot is to be ſprinkled over with pulverized glaſs of borax, and then kept for a few minutes at a white heat; when moderately cool it is to be plunged into dilute muriatic acid by which the borax and other vitreous matter will be diſſolved, leaving the platina with a perfectly clean white ſurface.

§. 4. *Phyſical and Chemical Properties of Platina.*

The colour of this metal is between tin-white and iron-grey. Its ductility and malleability are both very conſiderable as it may be drawn into fine wire, and be beaten into leaves as thin as tin-foil. It poſſeſſes a conſiderable elaſticity, and in hardneſs is not much inferior to iron; hence it may be made to receive a high poliſh. It is fuſible by galvaniſm, and by the concentrated rays of the ſun, but is ſcarcely to be melted by the most powerful furnace. At a full white heat it poſſeſſes the property of welding like iron, and two pieces may thus be made to unite with perfect accuracy. It is not oxydable by the higheſt heat, or the combined influence of the air and moiſture; hence it is entitled to rank among the noble or perfect metals.

The only acid menſtrua by which it is capable of being diſſolved are the oxymuriatic and nitromuriatic acids, the latter being moſt commonly employed for this purpoſe. Reſpecting the compoſition of this acid and the proportion of platina that it is capable of diſſolving there is very little agreement among chemiſts. The common method is to prepare the acid by mixing together equal parts of ſtrong aquafortis and fuming muriatic acid, and of this menſtruum from 16 to 24 parts are required for the ſolution of one of platina. By this mode of proceeding however there is a moſt unneceſſary waſte of nitric acid, and the ſolution always contains an exceſs of acid. A much more ſatisfactory reſult has been obtained by Prouſt,[f] and which appears to be the more worthy of credit as it is deduced from ſeveral experiments on a large ſcale. The acids employed by this able chemiſt were common ſtrong aquafortis of 35° Beaumé, and muriatic acid of 15°. A nitro-muriatic acid compoſed of theſe in the proportion of 4 oz. by weight of the former, and 12 oz. of the latter, being digeſted on 6 oz. of platina was found to take up 17¼ drachms; the ſolution being then concentrated by gentle diſtillation, the acid liquor that came over, weighing 10 oz. 1 drachm, after being ſtrengthened by 4 oz. of muriatic acid was found to be capable of taking up about 8½ drachms more of platina. Hence it appears that 16 oz. of muriatic acid, and 4 oz. of nitric are adequate by proper management to the ſolution of 26¼ drachms (3 oz. 2¼ dr.) of platina. In general a conſiderable quantity of acid is loſt by the imprudent application of heat in this proceſs, ſo that the beſt mode of performing this operation, eſpecially when any conſiderable quantity is employed, is to pour the whole of the muriatic acid on the platina in a retort with about ¼ of the nitric acid and allow them to act on each other in a moderate warmth till all effervеſcence has ceaſed; then to add another portion of nitric acid, and ſo on till the whole has been made uſe of; then to proceed to diſtillation, and after ſtrengthening the product with freſh muriatic acid to digeſt it on a freſh portion of platina; which being compleated both the ſolutions may be added together. If crude or imperfectly purified platina is employed, a portion of black matter will remain undiſſolved, and the colour of the ſolution will approach more or less to a deep orange brown inſtead of being orange yellow, the colour of pure muriat of platina.

Muriat of ammonia decompoſes this ſolution and throws down a triple ſalt, the ammoniaco-muriat of platina, which if pure is yellow, but of a brick red if combined with the other metallic oxyds. This ſalt is ſparingly ſoluble in boiling water; one ounce of it being boiled with repeated portions of pure water requires between 8 and 9 lbs. for its compleat ſolution.[g] If the ſalt is of a brick red colour the ſolution is yellowiſh red verging on green, and depoſits by ſtanding a little black matter, and changes to a bright orange colour, from which by repeated ſlow evaporation and cryſtallization may be obtained ſmall octohedral cryſtals of a high topaz colour. The yellow ammoniacal muriat when decompoſed by heat leaves behind about 42.5 per cent. of platina which is rapidly ſoluble in nitro-muriatic acid; the red ſalt on the other hand affords about 44 per cent. of metal, which is with difficulty acted on by aqua regia, and a ſmall portion in the form of a black powder abſolutely refuſes to diſſolve. That this red ſalt contains ſome other metal beſides platina is further obvious from this circumſtance, that if the reſidue after its decompoſition by heat be placed in a tube heated red hot, and expoſed to a ſtream of oxygen gas, a blue metallic oxyd will be volatilized, which appears to be the ſame with the iridium of Mr. Tennant. Ammoniaco-muriat of platina is alſo decompoſable by oxymuriatic or nitro muriatic acids which deſtroy the ammonia and reduce the ſolution to ſimple muriat. It is alſo in part at leaſt decompoſable by the cauſtic fixed alkalies and lime-water.

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[f] An. Chim. xxxviii. p. 231.

[g] Mouſſin Pouſchkin, An. Chim. xxiv. p. 205

Potaſh is alſo capable of uniting with muriat of platina forming with it a triple ſalt, the general properties of which are analogous to thoſe of the preceeding. Soda combines in like manner with muriat of platina into a triple ſalt. The moſt convenient way of preparing it is to mix with the muriat of platina a ſolution of common ſalt, from which by evaporation and cooling may be obtained long priſms or triangular tables of the ſalt in queſtion. The colour of this ſalt if the platina was pure is a bright yellow. It is very ſoluble not only in water but in alcohol, in which it differs from the two preceding ſalts; it is decompoſable by muriat of ammonia, which throws down the ammoniaco-muriat of platina; it is alſo decompoſable by the fixed alkalies either pure or cauſtic, but if they are added to exceſs the oxyd of platina is again diſſolved by them. When heated before the blow-pipe on charcoal this ſalt boils, and is decompoſed, the platina being reduced to the metallic ſtate.[b]

The ſulphuric, nitric, and oxalic acids, though they have no effect on the pure metal, diſſolve its oxyd and form with it ſalts that have hitherto been very little examined.

The ſalts of platina are not decompoſed either by gallic acid, infuſion of galls, or pruſſiat of potaſh. Sulphuretted hydrogen throws down a brown precipitate conſiſting for the moſt part of metallic platina.

The action of the cauſtic fixed alkalies at a high heat on platina is conſiderable, the metal being corroded and partly diſſolved, a circumſtance which conſiderably diminiſhes the uſe of crucibles formed of this ſubſtance in the analyſis of the more refractory ſtony minerals. Nitre produces a ſimilar effect. Mr. Tennant found[i] that by heating nitre with ſome thin pieces of platina in a cup of the ſame metal, the cup was much corroded and the thin pieces were entirely deſtroyed. By diſſolving the ſaline maſs in water the greater part of the platina was precipitated in the form of a brown powder. This powder was entirely ſoluble in muriatic acid, and conſiſted of oxyd of platina combined with potaſh. Part of the platina was retained by the alkaline ſolution to which it communicated a yellowiſh brown colour. On the addition of an acid an inſoluble triple ſalt was produced conſiſting of oxyd of platina, potaſh, and the acid employed.

Platina combines by fuſion with many of the metals. With gold it forms an alloy that has been already deſcribed. With ſilver it compoſes a moderately eaſily fuſible alloy, of a ſilvery white colour, conſiderably malleable, and capable of a high poliſh; but when heated red it becomes of an iron-black colour, bliſters and throws off ſcales ſo as to render it incapable of being wrought. A remarkable property of this alloy is that it is very apt on conſolidating from fuſion to become entirely covered with a ſort of imperfect cryſtallization, thus becoming as rough as the coarſeſt file. Lead combines without difficulty with platina at a full red heat, forming a ſomewhat malleable alloy of eaſy fuſibility; by cupellation a conſiderable portion of the lead is worked off, but the remaining alloy is too fuſible and too eaſily acted on by menſtrua to enable it to ſupply the place of pure platina as a material for crucibles, &c.

The ſpungy metallic maſs remaining after the decompoſition by heat of the ammoniaco-muriat of platina enters readily into combination with mercury, as we have already mentioned, forming an amalgam. If inſtead of the platina, the triple ſalt itſelf is triturated in an earthen ware mortar with an equal weight of mercury, the ſalt in a ſhort time, according to Mouſſin Pouſchkin, loſes its orange yellow colour, and paſſes firſt to brown and then to greeniſh brown; a ſecond portion of mercury brings the whole to the ſtate of a grey powder, a third cauſes a commencement of amalgamation, and by the time the ſixth is added the amalgam is compleated. If the amount of mercury is even nine times as great as that of the ſalt the amalgam will ſtill be very ſtiff and tenacious, and as brilliant as the beſt amalgam of tin. It is a remarkable property however of this mixture, that if it is triturated for a few minutes with water, or rubbed in the palm of the hand, it is rapidly converted into a grey powder which is oxyd of mercury, with ſeveral brilliant particles of platina diſperſed through it, and a little running mercury uſually alſo makes its appearance. This grey powder by ſublimation in a retort, furniſhes metallic mercury, and a little calomel.[k]

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[b] Deſcotils in An. Ch. xlviii. p. 165.

[i] Phil. Tranſ 1797, p. 221.

Platina is not capable of combining with ſulphur, but unites readily with phoſphorus, from which it cannot be ſeparated by mere heat.

§. 4. *Oſmium, Iridium, Rhodium and Palladium.* Of the above four new metals which have recently been diſcovered in crude platina ſo few particulars have as yet been obſerved that we have thought it moſt adviſable to treat of them in an appendix to the article platina.

It has been already mentioned that in diſſolving crude platina in nitro-muriatic acid, a black powder is ſeparated which has been ſuppoſed by ſome chemiſts to be oxyd of iron, by others has been conſidered as plumbago, but has been lately diſcovered by Mr. Tennant to contain two new metals. If in treating the crude platina a large proportion of ſtrong acid at a boiling temperature is made uſe of, nearly the whole of the black powder is diſſolved, and the platina thrown down from the ſolution by muriated ammonia inſtead of being yellow is of a brick-red. But if a weaker acid at a much lower temperature is employed, the ſolution is much leſs coloured and nearly 3 *per cent.* of this black powder remains, which may be readily ſeparated by filtration and waſhing.

[l]This black matter is partly in ſcales and partly pulverulent; it leaves black traces on paper as plumbago does, but differs remarkably from this latter in its sp. gr. which is = 10.7. It unites readily with lead, but the compound even if containing no more than $\frac{1}{11}$ of this black matter, poſſeſſes very little fluidity when melted. Nitrous acid diſſolves out the lead, leaving the other ingredient nearly in the ſame ſtate as at firſt. With biſmuth, zinc, and tin, the effects are nearly ſimilar; but with copper at a very high heat it contracts a more intimate union, for by digeſting the compound in nitro-muriatic acid ſome of the powder was taken up together with the copper forming a very dark-coloured ſolution.

With ſilver and gold it unites eaſily and intimately, and is incapable of being ſeparated from either by cupellation, or from gold even by quartation: the alloys retain conſiderable ductility, and the colour of that with gold is not materially different from pure gold.

If this black powder be mixed with a large proportion of cauſtic ſoda, and kept for ſome time at a red heat, in a ſilver crucible, the maſs acquires a browniſh-yellow colour. On the addition of water a peculiarly pungent odour is extricated and the alkali with part of the yellow powder is diſſolved. This alkaline ſolution contains the oxyds of OSMIUM and iridium, the former of which may be obtained pure by ſlightly ſuperſaturating the ſolution with ſulphuric acid and proceeding to diſtillation, the metallic oxyd being very volatile, riſing with the water and remaining in ſolution with this fluid in the receiver; as however a little ſulphuric acid is liable alſo to come over, a ſecond very gentle diſtillation is required to procure the oxyd quite pure. The ſolution thus obtained is as colourleſs as water; it has a ſweetiſh taſte and a ſtrong peculiar odour; it does not change vegetable blues to red. Oxyd of oſmium may be obtained in a much more concentrated ſtate by diſtilling the original black powder with nitre. When the materials approach to a red heat there ſublimes into the neck of the retort a fluid apparently oily, but which on cooling concretes into a ſolid colourleſs ſemi-tranſparent maſs. In this concentrated ſtate it ſtains the ſkin of a permanent dark colour. It is ſoluble in water, and then exhibits the properties of the above-mentioned ſolution. The ſalts of platina or gold when dropped into it produce no apparent chemical change, but with nitrat of lead it gives a yellowiſh brown precipitate, with nitrat of mercury a white one, and with muriat of tin a brown one. An infuſion of galls produces a purple colour which ſoon changes into a deep vivid blue. With pure ammonia or carbonat of ſoda it acquires a light yellow colour, and with lime a ſimilar colour but of a brighter tinge; this latter ſolution affords with infuſion of galls a deep red precipitate which becomes blue by acids. Pure magneſia or carbonat of lime produce no effect on this oxyd. On the addition of alcohol, the whole ſolution acquires a dark colour, and after ſome time the oſmium is depoſited (probably in the metallic ſtate) in the form of black films. A ſimilar effect, but much more ſpeedily, is produced by ether. The watery ſolution of this oxyd is decompoſed by all the metals except gold and platina, a black or dark grey precipitate being thrown down conſiſting of the mixed oxyds of oſmium and of the precipitant. A little mercury ſhaken with the above ſolution ſpeedily deprives it of all odour, and combines with the oſmium into an amalgam; this amalgam being expoſed to heat in cloſe veſſels, the mercury is volatilized and a dark grey or blue powder remains behind, which is the pure metal. When heated with acceſs of air it evaporates with the uſual odour; but if the air is carefully excluded it ſeems neither volatile nor fuſible even at a full white heat and in contact with charcoal. But when heated with copper or gold it melts with them forming uniform malleable alloys.

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[k] An. Ch. xxiv. p. 209.

[l] Tennant in Phil. Tranſ 1804, p. 412.

The pure metal after having been ſtrongly heated is not affected by nitro-muriatic acid, but when heated in a ſilver crucible with cauſtic alkali it combines readily with it, and gives a yellow ſolution, from which acids expel the oxyd of oſmium with its uſual properties.

We have already mentioned that the black powder obtained from crude platina, contains both oſmium and iridium. The method of ſeparating the former has been juſt now treated of, we ſhall now therefore proceed to ſhow how to procure the latter. Vauquelin's [m] method is to fuſe the black powder with four times its weight of cauſtic potaſh, which gives a green ſaline maſs: by digeſtion with water a green ſolution is obtained, and ſome green powder remains undiſſolved. The alkaline ſolution is to be ſaturated with muriatic acid, by which a green precipitate will be obtained, and this, together with the green powder, is to be digeſted in ſtrong muriatic acid. The deep green muriatic ſolution thus prepared, contains the oxyds of iridium, iron, and oſmium, and when heated to ebullition, its colour changes to a bright red. It is now to be gently evaporated to dryneſs, and the reſidue being treated with alcohol, the muriat of iron will be diſſolved, leaving behind a red powder entirely free from this metal. This red powder being calcined at a red heat in an open crucible, there firſt ariſes muriatic acid, and then a vapour which tinges the flame of the coals of a fine blue, and which doubtleſs is the oxyd of oſmium; a black powder remains behind, which, when mixed with borax and expoſed to a very high heat, is reduced into a half fuſed granular metal, of a white colour, and very brittle, which is pure IRIDIUM. The metal in this ſtate is ſoluble only in nitro-muriatic acid, and that in ſmall quantity, and with conſiderable difficulty. The colour of the ſolution is a very deep red, which is deſtroyed by green ſulphat of iron. It affords no precipitate with muriat of ammonia; with pruſſiat of potaſh it gives a brown precipitate, which becomes green by the action of the air. When added to a ſolution of pure platina, it cauſes the precipitate of this latter by ſal-ammoniac, to be of a deep-red colour, inſtead of the light yellow which it affords when pure.

Mr. Tennant ſeparated the iridium from the other metals with which it is mixed, in the following manner. He treated the black powder alternately with cauſtic ſoda, and muriatic acid: the acid ſolution, conſiſting chiefly of muriat of iridium, was of a dark-blue colour, which afterwards became of a duſky olive-green, and finally, by continuing the heat, of a deep-red colour. By ſlow evaporation of the ſolution only an imperfectly cryſtallized ſaline maſs was obtained, but this being dried on blotting paper and again diſſolved in water, afforded on evaporation diſtinct octohedral cryſtals. Theſe cryſtals are the pure muriat of iridium, and when diſſolved in water give a deep orange-red coloured ſolution. With an infuſion of galls no precipitate is formed, but the colour of the ſolution is inſtantly and almoſt entirely taken away. Muriat of tin, carbonat of ſoda, and pruſſiat of potaſh, produce nearly the ſame effect. Ammonia precipitates the oxyd, but if in exceſs, rediſſolves a portion, forming a purple liquor. The pure fixed alkalies throw down the oxyd of a brown colour, but retain a part in ſolution, and thus acquire a yellow colour. Muriat of iridium is decompoſed by all the metals except gold and platina, a black precipitate being thrown down, which doubtleſs is metallic iridium. It may alſo be obtained pure by heating the octohedral muriat, which expells the oxygen and acid; the metal remains of a white colour, and nearly infuſible. It does not combine either with ſulphur or arſenic; it unites with lead, but is readily ſeparable by cupellation. With copper it forms a very malleable alloy, as it alſo does with ſilver. Gold alloyed even with a conſiderable quantity of iridium, is perfectly malleable, and nearly of the ſame colour with pure gold: it is not ſeparable either by cupellation or quartation: by digeſtion in nitro-muriatic acid the gold is diſſolved, and the iridium remains behind in the form of a black powder.

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[m] An. de Ch. xlviii. p. 178.

All that is hitherto known of the newly-diſcovered metal called Rhodium, has been communicated to the public by Dr. Wollaſton.[n] It is thus procured. Some crude platina being digeſted in moderately dilute nitro-muriatic acid, a browniſh-red ſolution is obtained: from this the platina is to be ſeparated for the moſt part by muriat of ammonia, and the reſidual liquor is to be heated with zinc; by this treatment a black powder will be obtained, and the ſupernatant fluid will conſiſt of the muriats of zinc and iron. This black powder by digeſtion in very dilute nitric acid, will be freed from the copper and lead which it uſually contains, and the reſidue is to be digeſted in dilute nitro-muriatic acid, till every thing ſoluble is taken up. To this ſolution a little common ſalt is to be added, and the whole evaporated to dryneſs, after which, by repeatedly waſhing with warm alcohol, the ſoda-muriats of platina and palladium will be diſſolved, leaving behind a pure ſoda-muriat of rhodium.

This ſalt is readily ſoluble in hot water, and depoſits on cooling rhomboidal cryſtals of a bright roſe colour. Sal ammoniac occaſions no turbidneſs in the ſolution, but if a few drops of muriat of platina are added to the mixture, an immediate yellow precipitate is thrown down. Neither pruſſiat of potaſh, nor hydroſulphuret of ammonia, nor the carbonated alkalies, produce any precipitate; but the pure alkalies throw down a yellow oxyd reſoluble either in alkalies or acids.

The muriat of this metal is an uncryſtallizable ſalt of a roſe colour, and ſoluble in alcohol: with nitre or the muriats of ammonia or ſoda, are formed cryſtallizable triple ſalts inſoluble in alcohol.

Nitrat of rhodium is alſo uncryſtallizable. It appears not to be decompoſable by ſilver, but is ſo by copper, mercury, and moſt of the other metals.

The ſoda muriat of this metal affords a black powder by digeſtion with zinc, which when heated with borax, acquires a white metallic luſtre, but is infuſible by any heat that has hitherto been applied. It is however fuſible either with arſenic or ſulphur, and may be again ſeparated from theſe ſubſtances by heat, but it does not acquire by this treatment any degree of malleability. It combines with moſt metals, and with ſilver and gold forms very malleable alloys, which are unaltered by a high heat, but become encruſted with a black oxyd when ſlowly cooled. An alloy of 6 parts of gold and 1 of rhodium, differs but little in colour from fine gold, but is much more difficultly fuſible. The ſp. gr. of rhodium appears to be ſomewhat more than 11.

In the preceding account of rhodium, we have mentioned the method of ſeparating the ſoda-muriat of this metal from the ſoda-muriats of platina and palladium, by means of warm alcohol. This being done, the alcoholic ſolution is to be mixed with a ſolution of muriated ammonia, by which the greater part of the platina will be precipitated: the ſupernatant liquor being then poured off and diluted, there is to be added pruſſiat of potaſh, as long as any precipitate is produced. There is thus obtained a deep orange coloured ſediment, which changes by degrees to a dirty bottle green This when dried is to be heated with a little ſulphur, and fuſed into a button, after which it is to be ſtrongly heated with glaſs of borax, till on cooling it acquires a bright metallic ſurface; being now ſeparated from the borax and expoſed to the flame of the blowpipe, the ſulphur is volatilized, and there remains behind a ſpungy malleable metallic maſs, which is pure Palladium.[o]

This metal in its colour greatly reſembles platina; when rolled into a thin lamina it is very flexible, but not very elaſtic. Its ſpecific gravity varies from 10.9 to 11.9. Its hardneſs is ſomewhat ſuperior to that of bar iron; its fracture is fibrous, and it is very malleable. When heated below redneſs it acquires a ſuperficial blue tinge, but neither at this nor at a higher temperature, is there the leaſt appearance of oxydation. At a full white heat it enters into fuſion. It readily combines with ſulphur, and the compound is brittle, of a whiter colour than the pure metal, and fuſible at nearly the ſame degree as zinc.

Palladium unites with gold; and the alloy, when equal parts of the ingredients are uſed, is of a grey colour, equal in hardneſs to wrought iron, ſlightly malleable, and of a coarſe-grained fracture. Sp. gr. 11.07.

Equal parts of platina and palladium form an alloy reſembling the former ingredient in colour and hardneſs, but in fuſibility reſembling palladium. Sp. gr. 15.1.

Equal parts of palladium and ſilver produce an alloy ſomewhat harder than ſilver, and in colour reſembling platina, only whiter. Sp. gr. 11.2.

With an equal weight of copper this metal forms a yellowiſh alloy, harder than wrought iron, and ſomewhat brittle. Sp. gr. 10.3.

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[n] Phil. Trans. 1804. p. 419.

[o] Chenevix in Phil. Trans. 1803. p. 290. Wollaſton in ditto, 1804. p. 426.

With an equal weight of tin, a greyiſh alloy is produced, inferior in hardneſs to wrought iron, and extremely brittle: its texture is compact and fine-grained. Sp. gr. 8.1.

With an equal weight of biſmuth it gives a grey alloy, very brittle, and nearly as hard as ſteel. Sp. gr. 12.5.

Arſenic increaſes the fuſibility of this metal, and renders it very brittle.

Sulphuric acid, when boiled upon palladium, diſſolves a ſmall portion, and acquires a bright red colour. Muriatic acid alſo by long ebullition takes up a portion, and becomes of a red colour. Nitric acid, eſpecially when yellow and fuming, acts with vigour on this metal, converting it firſt into a red oxyd, and then diſſolving it. Nitro-muriatic acid is however the beſt ſolvent of palladium, and forms with it a beautiful red ſolution. From theſe acid ſolutions the alkalies and earths throw down precipitates, moſtly of a bright orange colour, which are partly rediſſolved by the alkalies if added in exceſs: the ſupernatant liquor of the precipitate by ammonia, is often of a greeniſh-blue. The ſulphats, nitrats, and muriats of potaſh or ammonia, produce an orange precipitate, as they do with the ſalts of platina. All the metals, except gold, platina, and ſilver, occaſion a copious precipitate of palladium in the metallic ſtate. Recent muriat of tin produces a dark orange or brown precipitate in the neutralized ſalts of palladium; but if added to exceſs, the liquor remains tranſparent and of a beautiful emerald green. Green ſulphat of iron throws down the palladium in the metallic ſtate. With pruſſiat of potaſh it forms an olive-green precipitate, and with ſulphuretted hydrogen a dark-brown one.

Theſe characters are ſufficient to diſtinguiſh palladium from platina, and every other of the known metals. It was ſuſpected by Mr. Chenevix to be a compound of mercury and platina, but the experiments of this gentleman having totally failed in the hands of other chemiſts, it muſt be conſidered, for the preſent at leaſt, as a diſtinct metallic ſpecies.

PLUMBAGO. See Coal. Sp. gr. 9.

PNEUMATIC APPARATUS. See Appendix.

POLIERSCHIEFER. Poliſhing ſlate.

Its colour is yellowiſh-grey, approaching to cream-colour; it is always ſtriped.

It occurs in maſs: it is dull internally. Its longitudinal fracture is ſlaty; the croſs fracture is earthy. Its fragments are tabular. It is ſoft; adheres to the tongue; is fine but meagre to the touch; and is ſometimes ſo light as to float on water.

It occurs in the vicinity of pſeudo-volcanoes in Bohemia.

PONDEROUS EARTH See Barytes.

PORCELAIN. See Pottery.

PORCELAIN, Reaumur's. See Glass.

PORPHYRY.

A large and important claſs of primitive rocks is diſtinguiſhed by modern mineralogiſts by the name of porphyry. It is eſſential to porphyry to conſiſt for the moſt part of a compact paſte, in which are implanted grains or ſolitary cryſtals of felſpar, of the ſame formation as the principal part of the rock. There are however ſeveral ſpecies of rock agreeing with this definition, which are however arranged among the primitive or ſecondary traps, and will therefore be treated of hereafter.

There are five ſpecies of rocks belonging to the proper porphyritic formation, namely,

1. Hornſtone porphyry. The hornſtone which ſerves as the baſe of this ſubſtance is generally red or green, with a conchoidal or ſplintery fracture; and it incloſes cryſtals of quartz and felſpar.

2. Felſpar porphyry. The baſe of this is commonly red compact felſpar, incloſing cryſtals of felſpar and quartz

3. Sienitic porphyry. This differs from the preceding in containing cryſtals of hornblende in addition to the other ingredients.

4. Pitchſtone porphyry. The baſe of this is pitchſtone, either red, green, brown, or black.

5. Clay porphyry, of which the baſe is indurated clay paſſing into hornſtone; it is generally of a reddiſh colour, and contains cryſtals of quartz and felſpar.

Mountains of porphyry are not ſtratified and never incloſe beds of other ſubſtances. Its texture is commonly compact but it occaſionally occurs in ſchiſtone. It is not very rich in mineral veins; the clay porphyry is the moſt ſo; the rich mines of Schemnitz in Hungary being in this ſpecies of rock.

The porphyritic formation is not very diſtinctly ſeparated from the other rock formations which accompany it, nor is its rank among the primitive mountains, with regard to antiquity, very clearly aſcertained.

Hornſtone porphyry ſeems to be the oldeſt of the claſs, and clay porphyry the moſt recent. The red porphyries are employed in ornamental architecture for columns, &c. and are much eſteemed.

PORZELLANERDE. See CLAY (*Porcelain.*)

POTASH *of Commerce.* See CARBONAT *of Potaſh.*

POTASH, *Vegetable Fixed Alkali. Gewachsalkali.* Germ.

The term potaſh, which originally ſignified one ſpecies of impure carbonat of potaſh, and is ſtill applied to it in commerce, is reſtricted in the modern chemical nomenclature to the pure vegetable fixed alkali free from carbonic acid or any other admixture.

The ſources of this alkali have been mentioned when deſcribing its carbonat, and it is *procured* entirely from the vegetable kingdom, but Klaproth has diſcovered that it forms about a fifth part of the compoſition of leucite and lepidolite, and probably will be detected in many other minerals now that analyſts are aware of its exiſtence in the mineral kingdom, ſo that ſtrictly ſpeaking, the term *vegetable* as applied excluſively to this alkali is incorrect.

Potaſh is eaſily prepared in tolerable purity, but with difficulty abſolutely ſo. For moſt purpoſes of chemical analyſis the following way is ſufficient.[a] Select a pure carbonat of potaſh, (made either by refining common pearlaſh, or by calcining cream of tartar, or deflagrating it with equal parts of nitre) boil it with ſufficient water in a poliſhed iron kettle with about half its weight of well burnt lime from white marble for a few minutes, ſtrain the liquor through linen, waſh the bulky maſs of ſlacked and carbonated lime once with hot water to extract the adhering alkali, add it to the firſt liquor, and without waiting to filter it, reduce the whole by boiling till it is of a thick ſyrupy conſiſtence; after which paſs it once more through linen and ſet it by in a glaſs bottle. In a day or two the liquor becomes perfectly clear, and may then be poured off from the ſediment, and kept in a well ſtopped glaſs bottle. Liquid potaſh thus prepared, if a very pure carbonat of potaſh be ſelected, will be ſufficiently pure for moſt experiments. The uſe of the lime is to abſorb the carbonic acid, and the preciſe quantity required for this purpoſe depends on the nature of the lime, and its perfect calcination. When too little lime has been uſed, the alkaline liquor ſtill retains a portion of carbonic acid, and will therefore become turbid with lime or barytic water, (which turbidneſs will diſappear on ſuperſaturation by any acid, whereby the precipitate is diſtinguiſhed from that formed by the preſence of a ſulphat). When too much lime has been employed, the ley contains lime in ſolution as well as perfectly cauſtic alkali, and will become turbid by adding carbonic acid or ſimply by blowing through it from the mouth for a time, or by a ſhort expoſure to the air. For the analyſis of earths therefore it is better to have a ſmall exceſs of carbonic acid, which effectually excludes lime. The lime ſhould be of Carrara marble or oyſter ſhells, which contain no alumine, as the latter earth is readily diſſolved by the alkali, and is with difficulty got rid of. The actual quantity of alkali in a given ſolution is determined by evaporating it to dryneſs in a ſilver crucible, and weighing the white ſolid alkali that is left. Liquid alkali prepared in this way is known to be pure (that is, free from earth,) by ſuper-ſaturating a little of it with *pure* nitric or muriatic acid, then adding carbonat of ammonia till it is ſenſibly ammoniacal, and boiling for a few minutes. If no earth be preſent no turbidneſs will enſue after ſtanding for ſeveral hours.

Potaſh as commonly prepared however, often contains, beſides the pure alkali, carbonic acid, ſulphat and muriat of potaſh, manganeſe, ſilex, alumine, and oxyd of iron. Of theſe, the three firſt if not in any conſiderable quantity are often of no importance in the analyſis of minerals, but it is neceſſary that the chemiſt ſhould know that they exiſt, and when required ſhould be able to free the alkali from them. The way of detecting the preſence of earths has juſt been mentioned; the ſulphuric acid may be ſhewn by firſt ſaturating the alkali by perfectly pure nitric or muriatic acid, and then applying a barytic teſt: and the muriatic acid may be diſcovered by firſt ſaturating with the nitric, and then precipitating the ſulphuric acid (if any) by nitrat or acetite of barytes, and laſtly teſting with nitrat of ſilver. The way of preparing potaſh perfectly pure is by cryſtallization of the pure alkali either from the watery ſolution or from the ſolution in alcohol. There are however ſome ſlight objections to each mode, though both of them anſwer ſufficiently well for all purpoſes when made with care.

When a ſolution of potaſh with the above impurities is evaporated gradually, as ſoon as it has reached a certain point of concentration, the ſulphat and muriat of potaſh begin to ſeparate, being much leſs ſoluble than the alkali itſelf, afterwards the carbonat of potaſh cryſtallizes, and laſtly the pure alkali, and the form of the latter cryſtals is ſo different from the reſt that they cannot be eaſily miſtaken. It ſhould always be remembered in theſe operations that potaſh is extremely greedy of carbonic acid, which it abſorbs from the air very ſpeedily, ſo that all evaporations ſhould be made as much as poſſible in narrow-mouthed veſſels, and at a boiling heat that the ſteam which is conſtantly paſſing off may preſerve the liquor from the contact of air. All ſlow evaporation in the open air is therefore entirely inadmiſſible, as it would allow the whole of the alkali to be converted into a carbonat.

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[a] Klaproth.

M. Lowitz of Peterſburgh, has given very good directions for obtaining pure cryſtals of potaſh by ſimple evaporation of the cauſtic ley, and Berthollet has explained with his uſual accuracy the proceſs by alcohol. That of Lowitz is the following:[b] make a ſtrong ley with carbonat of potaſh and lime in the uſual way, ſtrain it through cloth and evaporate it at a boiling heat in a veſſel of very clean iron till a ſtrong pellicle appears on the ſurface. Cover the veſſel, and let the liquor cool, by which moſt of the neutral ſalts and carbonat of potaſh cryſtallize. Pour off the clear ſolution and evaporate it further, during which ſcum off from the ſurface the ſaline pellicle as long as it forms. When this has ceaſed, remove it from the fire and ſtir it inceſſantly till cold. Then rediſſolve it in twice its weight of cold water, filter the ſolution and evaporate it in a glaſs retort (or what is better, a cloſe veſſel of ſilver or ſilver-plate) till it begins to depoſit regular cryſtals which are now pure potaſh. When all the cryſtals have depoſited, ſeparate them from the liquor (which is always brown) let them drain in a cloſe veſſel, rediſſolve them and again cryſtallize them as before till they form with water a perfectly tranſparent ſolution. The liquor by further evaporation will furniſh more of the cryſtals of potaſh till it is almoſt exhauſted. Some nicety of management is required in the laſt proceſs, for if the ſolution be too much concentrated before it cools, the whole congeals into a ſolid white maſs, which muſt be a little diluted, and again brought to a boiling heat in order to cryſtallize.

The cryſtals of potaſh formed in this way aſſume the form of very thin broad plates croſſing each other in every direction, and ſo compleatly ſhutting in the mother liquor, that a bottle full of the mixture of cryſtals and ſolution may often be inverted without ſpilling a drop of the liquor. When melted in a red heat in a ſilver veſſel, theſe cryſtals run into a maſs of a ſnowy whiteneſs.

The other method of obtaining pure potaſh is by means of alcohol. Of all the ſubſtances contained in common potaſh, namely potaſh, carbonat of potaſh, alumine, ſilex, ſulphat and muriat of potaſh, only the firſt is to any notable degree ſoluble in well rectified alcohol, ſo that the purification of potaſh would appear to be effected by this means with perfect accuracy and ſimplicity, and is ſo to a great degree, though the curious reſearches of Berthollet on this ſubject ſhew that there are ſome decompoſitions that take place, which might not be at firſt ſuſpected. The experiments of this excellent chemiſt are the following.[c] A cauſtic ley was prepared in the uſual way from common carbonat of potaſh and lime, and was boiled down in an iron veſſel till it began to thicken. It was then put into a retort and alcohol was poured on it, and boiled for a while till part of the ſpirit had diſtilled over. When cold, the retort contained two diſtinct liquors, the loweſt was of a dark colour, and at the bottom of it were a number of ſaline cryſtals, (which proved to be carbonat of potaſh) mixed with a black earthy matter: the upper liquor was leſs coloured, and conſiſted chiefly of the alcohol holding the potaſh in ſolution. The lower liquor was a ſaturated ſolution of carbonat of potaſh in water, and ſtrongly efferveſced with acids, and the earthy impurities were either obtained from the lime, or originally contained in the carbonat of potaſh employed. The alcoholic ſolution did not efferveſce with acids nor precipitate lime water, but it ſlightly troubled muriat of barytes and gave a ſmall quantity of efferveſcing precipitate, which ſhewed that ſome carbonat of potaſh was ſtill contained. This ſolution was then boiled in a retort till part of the alcohol had diſtilled off, and on cooling it ſeparated into two liquors immiſcible by ſhaking, the upper part of which appeared like a yellow oil, and gave no longer any indication of carbonic acid, and was now a ſolution of as pure potaſh as could be obtained. By evaporation, and cooling at a certain point of concentration, clear cryſtals of potaſh ſeparated, but the mother liquor gradually aſſumed a darker colour. The lower of theſe two liquors alſo contained conſiderably pure potaſh, which cryſtallized by evaporation, but it was mixed with ſome carbonat of potaſh, and the ſolvent was chiefly water with a very little alcohol. If the entire alcoholic ſolution of potaſh is diſtilled to dryneſs it becomes gradually of a very dark brown colour, and is then effervefcent, though it ſhewed no traces of carbonic acid before the boiling. The pure cryſtals of the alkali when ſimply heated, loſe their water of cryſtallization but do not acquire the property of effervefcing. But if theſe ſame cryſtals are diſſolved in freſh alcohol, the ſolution which when cold is clear and colourleſs, turns yellow as ſoon as boiling, by evaporation the colour deepens, and even when highly concentrated it now refuſes to cryſtallize, and at laſt when deſiccated, if water is added, though the alkali is rediſſolved, there remains a browniſh reſinous inſoluble matter.

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[b] An. Chim. tom. 22.

[c] Mem. de l'Acad. for 1783.

The action of alcohol on potaſh ſeems therefore to be the following: it firſt diſſolves the potaſh, and ſeparates from it the greater part of the carbonated alkali which common potaſh contains, but a ſmall portion of it is retained till the ſolution is concentrated, when the more watery part of the alcohol ſeparates from the purer ſpirit, and the carbonat of potaſh follows the former.

But beſides this, a ſeparate action is exerted by the potaſh on the alcohol, whereby the ſpirit is in part decompoſed, and furniſhes both carbonic acid and a blackiſh reſinous matter, and thus the alkali is again rendered ſlightly effervefcent, and the ſolution by diſſolving this reſinous matter becomes high coloured.

This gradual formation of carbonic acid by the action of potaſh on alcohol, which is not adverted to in Berthollet's original memoir, is fully proved by Pelletier, who ſhews that the ſame change will take place even without heat, when the ſolution is kept for a conſiderable time, and the whole alkali is gradually changed to a carbonat.

From what has been obſerved, it will follow that the alcohol ſhould be allowed to remain only a ſhort time on the potaſh, and the pureſt poſſible alkali may be prepared ſimply in the following way: ſelect a very pure carbonat of potaſh, render it cauſtic by lime, (leaving rather a little carbonic acid than an exceſs of lime,) boil down the ley to dryneſs, then add highly rectified alcohol, and boil the mixture for a minute or two, and ſet it by in a well cloſed veſſel. Then pour off the alcoholic ſolution, evaporate it rapidly, and immediately bring it to perfect dryneſs, which will leave a white ſaline maſs, ſometimes covered with a black cruſt which may be removed, and the reſt is as pure potaſh as can be required for chemical purpoſes, containing no earth nor other foreign ingredient than a little of the reſinous matter from the alcohol, which is of no importance in analyſis. Or if abſolute purity is required, the cryſtals of potaſh ſeparated from the alcoholic ſolution may be employed.

The method of aſſaying alkali for earth and carbonic acid has been mentioned, but it may be right to notice a cauſe of miſtake which may occur. If to a very concentrated ſolution of perfectly pure potaſh in alcohol be added lime water, or muriated barytes, or barytic water, a precipitate will occur which might lead to ſuppoſe that carbonic acid was preſent, but in this caſe the precipitate is pure lime or barytes, and not a carbonated earth, which is ſeparated from its ſolvent by the alcohol of the ſolution, and is rediſſolved on adding diſtilled water, which the carbonated earth is not.

In preparing cauſtic potaſh it ſhould be remembered that the ſolution of potaſh at a boiling heat when highly concentrated, readily acts upon glaſs, and ſoon diſſolves a ſufficient quantity materially to alter and impair its purity. In this caſe it gives a gelatinous precipitate with acids, which is the ſilex of the glaſs. Therefore in preparing the alkali, all boiling and evaporating when the liquor is concentrated ſhould be performed in bright iron veſſels, or (for perfect purity) in thoſe of ſilver or plated copper.

The alcohol diſtilled off potaſh carries up with it ſufficient alkali to turn ſyrup of violets green.[d]

Potaſh is a ſimple ſubſtance as far as has been hitherto examined, though there is ſome reaſon for ſuſpecting it to be a compound. When ſolid and dry it is a white ſalt intenſely acrid to the taſte, and corroding the ſkin of the tongue almoſt inſtantly.

It exerts the ſame action on every other part of the body, ſo that when touched with the moiſtened hand it has a greaſy feel, owing to the inſtant action which it begins upon the cuticle of the fingers. It is extremely ſoluble in water, and is one of the moſt deliqueſcent ſubſtances known and hence it is uſefully employed in experiments to abſorb moiſture from any gas in which it is confined. Along with moiſture it abſorbs carbonic acid with great rapidity.

Potaſh melts at a moderately red heat and then runs into a clear liquid as thin as water, which becomes opake on cooling, and generally aſſumes a greeniſh tinge, the cauſe of which is not well known. At a full red heat (ſuch as that of melting copper) potaſh is readily volatilized, and flies off in a denſe vapour which is eaſily perceived when a crucible holding it thus heated is ſuddenly uncovered. This vapour is potaſh unaltered.

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[d] Berthollet.

Potaſh diſſolves all earths with extreme facility by fuſion, and even in watery ſolution with the aſſiſtance of heat. The mixture of potaſh and earth is ſoluble in water when the alkali is in exceſs, and the ſolution depoſits the earth when ſaturated by an acid.

Potaſh when ſolid and deprived of its water of cryſtallization produces a ſenſible heat when mixed with water; but the *cryſtals* of potaſh form with ſnow or powdered ice one of the moſt powerful freezing mixtures that is known, and which is deſcribed under the article *Freezing*.

Potaſh unites with all acids, producing ſalts that are deſcribed under theſe articles reſpectively or thoſe immediately ſucceeding. For the general properties which it poſſeſſes ſee *Alkali*: and for its action upon the *earths* in the moiſt or dry way upon *Oils*, *Sulphur*, *Phoſphorus*, ſee theſe articles and thoſe of *Soap* and *Glaſs*.

Potaſh when highly concentrated is very apt to cauſe glaſs phials in which it is kept to crack. It alſo ſeems to contract a very cloſe union with glaſs in any form, ſo that the drop or two which wets the ſpace between the ſtopper and the neck of the phial, will after a while cement it together ſo ſtrongly as to require much pains and perſeverance to ſeparate them unleſs previouſly oiled.

An impure potaſh melted and caſt into moulds, is uſed in ſurgery as a valuable and powerful cauſtic. It is mixed with ſoap, and applied in the form of a ſoft paſte to the ſkin, and in ſome hours it deſtroys the life of the part to which it is applied, which portion after a while comes out in the form of a deep ſlough.

This alkali reſembles ſoda ſo cloſely in taſte, appearance, and general chemical properties, that they are not readily diſtinguiſhable in any other way than by uniting them with the ſeveral acids and examining the neutral ſalts reſulting from this combination. The ſalts that are moſt readily diſtinguiſhable are the ſulphats, nitrats, and tartrites. Thus the ſulphat of potaſh is a hard bitter ſalt, requiring much water for ſolution, and therefore a ſaline precipitate of ſulphat of potaſh is formed when the acid and alkaline ſolution are ſomewhat concentrated when added: whereas the ſulphat of ſoda is very ſoluble, and differs eſſentially in its form of cryſtallization from the other. The nitrat of potaſh cryſtallizes in long ſix-ſided priſms, but the nitrat of ſoda in cubes. The acid of tartar alſo is a very uſeful teſt. If the alkali to be examined is firſt diſſolved in muriatic or any other acid, and a ſolution of tartareous acid added, if the ſalt has potaſh for its baſis, there will be a precipitate of tartar in a few ſeconds, but the mixture will remain clear if the baſis of the ſalt is ſoda. The nitro-muriat of platina alſo decompoſes all ſalts with potaſh, but not with ſoda.

The affinities of potaſh are in the following order: the ſulphuric acid, nitric, muriatic, phoſphoric, fluoric, oxalic, tartaric, arſenic, ſuccinic, citric, ſulphureous, acetic, carbonic and pruſſic.

This order however, as in other caſes of affinity, is to be taken with very conſiderable limitations, and in particular does not apply where the ſame acid forms both an acidulous and a neutral ſalt with potaſh, as in the caſe of the tartareous juſt mentioned, which will partially decompoſe even ſulphat of potaſh, that is, to the point at which the acidulous tartrite is formed, but no further.

POTTER'S LEAD ORE is the term uſually given to the common galena. See LEAD.

POTTERY AND PORCELAIN.

Our limits would not allow us (even if we had the means) to enter into any detailed deſcription of the antient and beautiful and moſt uſeful art of pottery, eſpecially as the moſt eſſential part of it can hardly be called a chemical operation, though conſiderably connected with chemiſtry in many of the ſubordinate parts. We ſhall therefore give but a ſingle example of the proceſs by which a lump of plaſtic earth is converted into a hard brittle veſſel, and add ſome obſervations on that part of the manufacture which is peculiarly deſtined for chemical uſes.

The eſſential material of pottery is clay, which alone poſſeſſes the two requiſite qualities firſt, of being in its natural ſtate ſo plaſtic that with water it becomes a ſoft uniformly extenſible maſs, capable of taking and retaining any form, and ſecondly, that when it is thoroughly dried and has undergone a red heat for a time, it loſes this plaſticity, is no longer retentive of water to any conſiderable degree, becomes hard, cloſe in texture, and able more or leſs perfectly to retain all liquids contained within its hollow.

The various compoſition of *Clay* has been deſcribed under that article and *Alumine*, and it has been there ſhewn, that though clay owes its plaſticity to alumine, it ſeldom contains ſo much of this as of other earths, and is in fact a very compound ſubſtance.

Many of the impure coloured natural clays are of themſelves ſufficiently mixed with other earths for the potter's uſe without addition, but the white and finer clays moſtly require dilution with ſilex in one form or other, which can be done to a very conſiderable degree without taking away the plaſticity requiſite for working.

The moſt material circumſtances required to be conſidered in ſelecting the materials for pottery appear to be chiefly plaſticity, ſhrinkage, ſolidity, and compactneſs after drying; colour, and fuſibility.

The plaſticity ſeems to be ſimply owing to the quantity of clay uſed, that is to ſay, relatively to the original plaſticity of the clay itſelf, for this quality is not the ſame in all clays equally aluminous, but is much leſs in proportion in the indurated clays, and is increaſed by expoſure to air.

The texture, including the qualities of hardneſs and compactneſs, depends partly on the mixture of ſiliceous ingredient with the clay, and partly on the heat employed in the burning of the pottery. The purer natural clays are almoſt infuſible in any furnace-heat, their hardneſs is nearly progreſſive with the intenſity of the fire, but they have the eſſential defects of drying very ſlowly, of ſhrinking very conſiderably, and of becoming rifty or full of minute cracks when dried, ſo as on this account to be porous. It is therefore neceſſary to mix them intimately with any other earth of qualities oppoſite to thoſe of clay, that is, which abſorbs but little water and readily parts with it, (qualities directly oppoſite to plaſticity) and which dries compact and cloſe.

The colour of the earths uſed is alſo of eſſential importance in the finer pottery, in which the great deſideratum is to find a clay which *after burning* remains perfectly white. The appearance before burning cannot always be depended on, for though in general the whiteſt clays before burning are thoſe that remain white afterwards, it is only in a few diſtricts where clays are found that remain abſolutely white. Thus there is found at the foot of a range of high hills that directly overlook the Staffordſhire potteries, a ſtratum of white clay to appearance fully equal if not ſuperior to the beſt Devonſhire clays, but it cannot be employed for the fine pottery, as it acquires in burning a yellowiſh cream colour, which no art can correct. The colour is ſuppoſed to depend on iron.

The fuſibility of clays and other pottery earths is a ſubject of extreme importance as it is on this that the diſtinction between *Pottery* and *Porcelain* chiefly depends.

Under the article *Glaſs* we have treated at conſiderable length on the fuſibility of earthy mixtures, to which therefore we ſhall refer our readers. Porcelain may be defined to be a ſpecies of pottery ware compoſed of an earthy mixture which reſiſts compleat fuſion in a very conſiderable heat, but has been brought by a leſs heat than its melting point to a ſtate of incipient fuſion, and thereby acquired extreme hardneſs, ſonorouſneſs, ſemitranſparency, and a ſemi-conchoidal ſplintery fracture, approaching to the vitreous which is compleatly conchoidal. This laſt is quite a diſtinctive character between porcelain and pottery, for the fracture of the latter is ſimply granular. It appears probable therefore that no chemical action takes place in any pottery mixture till it arrives at the ſtate of porcelain. The moſt perfect and beautiful porcelains of Japan and China are compoſed (as appears from the beſt teſtimony) of one earth in which ſilex predominates, and which melts in a ſtrong fire, and of another which is infuſible *per ſe*, and by an union of theſe alone (as it appears) a porcelain is produced which ſcarcely vitrifies at the utmoſt furnace heat which art can produce. This ſubſtance has the united excellencies of being very hard, of a beautiful ſemi-tranſparence, very white where not artificially coloured, very tough and coheſive, ſo that it has ſtrength enough for the purpoſes for which it is deſigned when made very thin, and it bears ſudden heating and cooling without cracking.

Of the beautiful European porcelains which have been made in imitation of the oriental, it ſhould ſeem that none of them preciſely unites all its diſtinguiſhing qualities. Earthy mixtures have been made equally ſtrong, tough, and infuſible, and as truly porcellanous when burnt, but theſe have not exactly equalled the beſt Japaneſe in delicate whiteneſs and luſtre. But as the latter are the moſt eſſential qualities, that of infuſibility has been in general ſacrificed, (which indeed is of no conſequence for any of the common uſes of porcelain) and therefore thoſe that come up to the oriental in beauty and delicacy, of which there are ſeveral manufactures in different parts of Europe, for the moſt part ſoften and melt down in the moſt intenſe heat of a wind-furnace, at which the true Nankin and Japaneſe undergo no change.

The manufacture of the ordinary pottery is on the whole very ſimple, where the due ſelection of materials is made, but it is the more delicate ornamental part, the modelling, enamelling, painting, gilding, &c. which diſplays ſo much exquiſite beauty and which requires a combination of perſeverance, ſkill, and pracical nicety of management, that is hardly equalled in any other chemical manufacture.

The intimate mixture of the ingredients uſed in pottery is of great importance to the beauty, compactneſs and ſoundneſs of the ware. Formerly the wet clay and ground flint (or whatever was the other material) were beaten together with great and long-continued manual labour, no more water being added than was neceſſary to render the clay thoroughly plaſtic. This laborious (and therefore expenſive) method has now been laid aſide in the larger potteries, and the ingenious way has been ſubſtituted of bringing each material firſt to an impalpable powder, and diffuſing them ſeparately in as much water as will bring them to the conſiſtence of thick cream, mixing them in due proportion by meaſure, and when thoroughly ſtirred together, evaporating the ſuperfluous water till the maſs is brought to a due conſiſtence for working.

The following is the common proceſs uſed in Staffordſhire for making the ordinary ware. The materials are a fine clay brought chiefly from Devonſhire, and a ſiliceous ſtone called *Chert*, or elſe common flint reduced to powder by heating red hot, quenching in water, and then grinding by wind-mills to a ſubtle powder. Each material is paſſed through fine braſs ſieves, then diffuſed in water, mixed by meaſure, and brought to a plaſtic ſtate in the way juſt mentioned. A lump of this is then thrown on the potter's wheel, and by the workman's hands aſſiſted by a ſmall blunt iron knife-blade it is faſhioned into the ſhape required, when circular, ſuch as cups, ſaucers, plates, &c. but when made oval, or to any pattern form, it is moulded on a plaſter model. Handles and ſpouts are then ſtuck on if required, and the piece after being again ſmoothed and the ſhape more accurately touched up, is ſet to dry for ſome days in a warm room, where it becomes ſo hard as to bear handling without altering its ſhape. When dry enough, it is encloſed along with many others in baked clay caſes of the ſhape of band-boxes, called *ſeggars*, which are made of the coarſe clays of the country. Theſe are next ranged in the kiln or furnace ſo as to fill it except a ſpace in the middle for the fuel. Here the ware is baked till it has remained fully red-hot for a conſiderable time, which in the larger kilns conſumes 10 or 15 tons of coal, after which the fire is allowed to go out, and when all is cooled, the ſeggars are taken out and their contents unpacked. The entire contents of one kiln will ſometimes exceed 30,000 different pieces of pottery. The ware is then in the ſtate of *biſcuit*; it is perfect pottery, very hard, beautifully white with a ſlight ſhade of yellow, and of a ſmooth ſurface, quite void of gloſs, much reſembling a clean egg-ſhell.

The next proceſs is the glazing, which is performed on all pottery intended for domeſtic uſe. For this purpoſe the biſcuit ware is dipped in a tub containing a mixture of about 60 parts of litharge, 10 of clay, and 20 of ground flint, diffuſed in water to a creamy conſiſtence, and when taken out enough adheres to the piece to give an uniform glazing when again heated. The pieces are then again packed up in the ſaggars, with ſmall bits of pottery interpoſed between each, and fixed in a kiln as before. The glazing mixture fuſes at a very moderate heat and gives an uniform gloſſy coating, which finiſhes the proceſs when it is intended for the common white ware. But the painting and gilding, each require ſeparate proceſſes.

Something may be added in this place on the pottery employed in chemical operations. Formerly when chemiſts made their own crucibles, muffles, &c. this was a very important branch of practical knowledge to every chemiſt, but at preſent this is almoſt wholly confined to the manufacturer, and we are only able to point out ſome of the leading circumſtances which determine the goodneſs of pottery ware for one or other purpoſe.

Some very eminent chemiſts, among whom we may enumerate Glauber, Agricola, and Pott,[a] have paid particular attention to this ſubject, and that enlightened manufacturer, the late Mr. Wedgewood, has introduced a ſpecies of ware which anſwers ſome important purpoſes better than any hitherto invented.

Three important requiſites are demanded to conſtitute a perfect pottery for all chemical purpoſes, namely, infuſibility at any heat; compactneſs of texture ſo as to retain ſaline and other fluxes in fuſion without being materially acted on by them, or allowing them to tranſpire; and endurance of ſudden changes of temperature, particularly ſudden heating without cracking or giving way in any degree.

Theſe three requiſites however have been found impracticable to be united in the ſame ware, which has led to the neceſſity of ſelecting the ſpecies of ware according to the intended uſe. For enduring the higheſt heat without ſinking, no veſſels have been found ſo uſeful as the Heſſian crucibles, which are made according to Pott, by mixing a very refractory clay with ſand, the fineſt part of which is ſeparated by a ſieve and rejected. Theſe veſſels are not turned in the potter's wheel as common pottery is, but the clay is made into a much ſtiffer maſs with leſs water, and is faſhioned into the required ſhape by being ſtrongly rammed into an iron mould. This gives them ſuch a degree of compactneſs that they will retain ſaline fluxes for a conſiderable time.

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[a] Mem. de l'Acad. de Berlin, for 1750.

With regard to this latter circumſtance, no earthy mixture can be made which will not be acted on more or leſs by ſaline fluxes, and alſo by the vitrified metallic oxyds, as has been mentioned under the article *Glaſs*, and this is particularly the caſe with the vitrified oxyd of lead, which has long been uſed as a kind of teſt of the retentive power of crucibles, as it paſſes through the ordinary porous crucibles in a ſhort time almoſt with as much eaſe as liquids through a ſieve.

Ordinary crucibles may be made more retentive by being lined on the inſide before they are quite dry with a thin coating of pure clay without any other mixture.

The moſt refractory material known is a mixture of unburnt with burnt clay, and one that reſiſts the operation of ſaline fluxes longer than any other, and hence it is employed in the making of the large crucibles for the glaſs houſe as deſcribed under the article *Glaſs*. The cloſe denſe porcelain alſo retains ſaline matters long without being materially acted on.

It is of conſiderable importance in fire-veſſels that they ſhould be able to bear heating and cooling with tolerable quickneſs, but it unfortunately happens that ſome of the moſt perfect ware in every other reſpect, is very deficient in this, and will even hardly bear the draught and flame of a wind furnace, however ſlowly heated, without danger of cracking. This is particularly the caſe with the valuable porcelain fire-ware invented by Mr. Wedgewood. This property of cracking on ſudden changes of temperature, appears particularly to depend on the two circumſtances of hardneſs and cloſeneſs of texture, and the latter is the greateſt (ceteris paribus) in proportion to the fineneſs of diviſion of the materials before burning. Thus in the ware juſt mentioned, both the clay and flint are brought to a moſt impalpable powder before mixture, and the texture is uncommonly hard and cloſe; and on the other hand, it has been found neceſſary in making the beſt Heſſian and other crucibles, to ſeparate and *reject* the finer part of the ſiliceous ingredient, for the expreſs purpoſe of enabling it to bear the ſtrong draught of the wind furnace. The Wedgewood ware ſtands ſudden heating and cooling better when it is covered with a thin coating of Windſor loam, or of a fire-lute compoſed of clay and coarſe ſand, and tow or horſe-dung.

Crucibles intended merely for the fuſion of metals, are much improved by a mixture of black lead. This material is protected from acceſs of air by being involved in the clay, and is then incombuſtible, and its abſolute infuſibility and want of affinity with earths at any temperature, enable the clay to undergo a very high heat without melting. Beſides the ſoftneſs and ſmoothneſs of the plumbago enables the veſſel to afford a very uniform ſurface without knots or projections, which in the common rough ware are apt to detain a portion of melted metal whilſt pouring out. This ware will alſo bear ſudden heating and cooling better than any other, ſo that ſcarcely any precaution is requiſite on this account, but its ſoftneſs and porouſneſs render it quite unfit for holding any ſaline or other flux.

The moſt porous ſubſtance uſed for fire-veſſels is bone-aſh, which is therefore only employed when this quality is an advantage, as in the proceſs of cupellation, already fully deſcribed under the article *Aſſay*. Here it acts like a ſponge in abſorbing the vitrified oxyd of lead, and only the reguline metal remains.

Of the earthen veſſels intended to hold acid or corroſive liquors in diſtillation, no ware is ſo perfect as the white Wedgewood porcelain ware already mentioned, its texture being ſo cloſe as not to require any lead-glazing. The only defect of this is the danger of cracking on any ſudden change of temperature.

But even this as all other pottery ware when unglazed, becomes in ſome degree pervious when heated fully red-hot, ſo that it cannot be depended on at this heat to confine gaſſes when under any preſſure. This accounts for the total diſappearance of diamonds when encloſed in lumps of fine porcelain clay and baked in an intenſe fire, as was found in ſome of the earlier experiments on this ſubſtance, and could not be explained till the diſcovery of the total converſion of this gem into carbonic acid gas by combuſtion. This permeability of unglazed porcelain ware alſo explains ſome objections brought to the antiphlogiſtic theory by the admixture of carbonic acid gas with azot when the latter is paſſed through red-hot porcelain tubes, which does not take place in glaſs tubes. The carbonic acid therefore ariſes from the burning fuel, and paſſes through the pores of the tube when red hot.

POTSTONE. *Topfſtein*, Germ. *Pierre ollaire*, Fr.

The colour of this mineral is greeniſh grey. It occurs in maſs. Its internal luſtre is gliſtening and pearly. Its fracture is curved, foliated, and imperfectly ſlaty. Its fragments are tabular. It is often tranſlucent on the edges. It is ſoft, is greaſy to the touch; tough and difficultly frangible. It is found in beds with ſerpentine, at Como in the Griſon country, and in Saxony. It may be turned in a lathe, and is made into a variety of veſſels. It is alſo uſed as a lining for furnaces, being remarkably refractory.

POWDER OF CASSIUS. See Gold.

PRASE. See Quartz.

PRECIPITATE. *Niederſchlag*, Germ.

A chemical precipitate properly means a viſible *ſubſidence* of any ſubſtance from its clear ſolution, produced by any method whatever, and it is generally applied when the ſeparation takes place in a flocculent or pulverulent form, in oppoſition to *cryſtallization*, which implies a ſimilar ſeparation in an angular polyhedral form. Thus even a maſs of cryſtals may be termed a *precipitate*, when their ſubſidence is ſo ſudden that their proper cryſtalline ſhape cannot be diſtinguiſhed by the naked eye, as when Glauber's ſalt is ſuddenly ſeparated in very minute cryſtals from its ſaturated watery ſolution by the affuſion of alcohol.

But precipitation may be taken in a more extended ſenſe to mean any viſible ſeparation of any ſubſtance or compound, from its clear ſolution, whether it ſinks or ſwims, and whether it be cryſtallized or pulverulent, and it then forms one of the great operations in chemiſtry, and is directly oppoſed to that of ſolution; for in fact by far the greateſt part of the operations of the chemiſt may be reſolved into ſolution and precipitation.

The mode in which precipitation affects and modifies chemical *affinity*, has been mentioned under that article, and Berthollet has ſhewn in his valuable eſſays on chemical affinity and on chemical ſtatics, how philoſophers have been led to deduce the ſuppoſed order of affinities from the circumſtances of precipitation.

The following remarks on the precipitations effected by acids or by alkalies and earths may be added from the ſame author.[a] The important ſubject of metallic precipitates will be noticed ſeparately.

There are two principal kinds of precipitates which have been diſtinguiſhed by chemiſtry, one where to a compound compoſed of an acid and a baſe, each highly ſoluble in water, another acid is added, which has a greater affinity with the baſe, and forms with it a compound leſs ſoluble than the firſt. In this caſe the precipitate (which is ſometimes cryſtallized, ſometimes otherwiſe) is compoſed of the acid laſt added, in proportions that vary but little. As for example when ſulphuric acid is added to a ſaturated ſolution of nitrat of potaſh a cryſtallized precipitate of ſulphat of potaſh is added, the *proportions* of which ſcarcely vary in any circumſtances, though the actual *quantity* of precipitate is determined by the quantity of water and of ſulphuric acid preſent.

Another kind of precipitate is that which has uſually been ſuppoſed to be ſimple, and takes place when to a compound of an acid and a baſe inſoluble (or nearly ſo) in water, an alkali or ſoluble earth is added, which by elective affinity unites with the acid, and diſplaces the former baſe; and this latter now ſuppoſed to be uncombined and inſoluble in the quantity of liquid preſent, falls to the bottom. This kind of precipitation is conſtantly reſorted to when we wiſh to obtain the ſimple earths, as in adding an alkali to a ſolution of alum in order to precipitate the alumine, to Epſom ſalt to precitate magneſia, &c. But the precipitate in all ſuch caſes is not (as has been uſually ſuppoſed) the ſimple earth, but it always retains after the firſt operation a ſmall and variable portion of the acid with which it was before combined. Thus if the alumine, however well edulcorated, be rediſſolved in muriatic acid, and a ſalt of barytes added, there will be a ſenſible precipitate of ſulphat of barytes. This *retent* of acid is variable and may be reduced to an inſenſible quantity, if not abſolutely taken away, by ſubſequent digeſtion in very concentrated alkali. Such precipitations therefore are not effected merely by ſimple affinity, but by a diviſion of the acid into two portions, one of which, and by much the largeſt, goes to the alkali, and the other remains with the earth and accompanies it in its precipitation. Even when no precipitation occurs, the acid may be proved to diſtribute itſelf in this manner, for as Bergman has remarked, if a calcareous ſalt is diſſolved in fifty times its weight of water, and an exceſs of potaſh or ſoda is added, no precipitation takes place, ſo that the acid continues in part to act upon the lime and renders it ſoluble in a much leſs quantity of water than the lime alone would require for ſolution.

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[a] Chemical ſtatics, vol. I.

It may be aſſumed therefore as a general principle, and one which is of great importance in the explanation of chemical decompoſition, that where a ſalt is compoſed of an acid and a baſe, inſoluble or little ſoluble by itſelf, the decompoſition effected by any ſoluble baſe is the reſult not of a ſimple but a compound action, in which on the one hand the decompoſing baſe unites with more or leſs of the acid and remains in ſolution, whilſt the other baſe reſumes its inſolubility by the ſeparation of part of its acid, and forms a precipitate with the remainder. This will be found to apply ſtill more ſtrikingly in the formation of metallic precipitates, and of thoſe ſalts which (like the ſub-ſulphat of mercury or turbith) were formerly taken for ſimple oxyds, but are now found to be ſalts with exceſs of oxyd.

Chemical affinity is in many caſes determined by precipitation, but a contradiction in the mode of applying this principle has been well pointed out by Berthollet.

The orders of affinity which the ſeveral baſes have for the acids is uſually determined by adding any baſe to a known combination of an acid and another baſe, and if the latter baſe is precipitated it has been inferred that its affinity for the acid is leſs than that of the other baſe. Thus when lime is precipitated by adding potaſh to muriat of lime, it is inferred that potaſh has a ſtronger affinity for muriatic acid than lime, and hence the preference in the order of affinity has been given to the moſt ſoluble baſes. But on the other hand, the reſpective affinities of the acids has been determined in the contrary way, as for example, when oxalic acid is added to muriat of lime a precipitate of oxalat of lime is produced, whence the ſuperior affinity of the oxalic acid over the muriatic for lime has been deduced. Thus in theſe caſes the preference in affinity has been given to thoſe acids which have the moſt diſpoſition to form inſoluble combinations.

But many inſtances may be given to ſhew that the phenomena of precipitation are diſtinct from thoſe of chemical affinity, ſo that the reſulting inſolubility or force of coheſion which produces precipitations. is ſometimes ſuperadded to the ſimple force of affinity, and at other times oppoſed to it, and ought in ſtrictneſs to be always conſidered as a diſtinct principle.

Of Metallic Precipitates.

The metal of every metallic ſolution in any acid is always in the ſtate of an oxyd, ſo that the ſolution muſt contain at leaſt three ſubſtances, the acid, the metal, and oxygen united with the metal. But the proportion of the latter is ſubject to a great number of variations, and is different both with the ſeveral metals and with the ſame metal in different circumſtances.

A metallic ſolution may be decompoſed and its metallic part precipitated either in the reguline ſtate or as an oxyd, and theſe two methods, which have each been adopted in the analyſis of metallic bodies, require to be conſidered ſeparately.

When a carbonated alkali is added to a metallic ſolution, the precipitate is a carbonated oxyd of the metal, and like the other carbonats effervеſces on the addition of a ſtronger acid. But when a pure alkali is added only to ſaturation, the precipitate is in ſome inſtances nearly a pure oxyd, but in the greater number is an oxyd retaining a ſmall portion of the acid with which it was united. This acid however is not ſufficient to render it ſoluble and it may be generally entirely taken away by ſubſequent digeſtion in a concentrated fixed alkali provided the oxyd is not ſoluble therein.

The firſt action of alkalies therefore on moſt metallic ſolutions is to cauſe an unequal diviſion of the acid, the greater part of which unites with the alkali, and the remainder falls down along with the oxyd now rendered inſoluble. If ammonia be the alkali employed, there is alſo in general a partition of the alkali, and the precipitate is a quadruple compound, of the metal, the oxygen united with it, and a ſmall portion of the acid, and of the ammonia; and the ſolution contains the greater part of the acid, of the alkali, and often a ſmall part of the metallic oxyd ſufficient to be very ſenſible to the taſte, and to chemical teſts. According to Prouſt, lime alſo when uſed as a precipitant enters in a ſmall proportion into the precipitate.

Metallic ſolutions ſometimes yield precipitates on the mere addition of water, by the ſimple diſtribution of the conſtituents into two portions, a ſoluble and an inſoluble one, the former of which has an exceſs of acid, and the latter of oxyd. Thus when the clear nitrat of biſmuth is diluted with water a white precipitate falls down which is chiefly oxyd of biſmuth, and the ſupernatant liquor contains an exceſs of acid and a ſmall portion of metal which may be ſeparated by evaporation or by an alkali. In like manner if ſulphuric acid and mercury are treated together, ſulphureous acid is given out, and the white maſs that remains is an uniform acid ſulphat, which deliqueſces into a denſe ſolution. But if hot water be added, the *turbeth* or yellow *ſub-ſulphat* of mercury is precipitated, and the ſolution contains an acid ſulphat. Even the firſt turbith may be further decompoſed by a freſh affuſion of hot water dividing it into a turbith ſtill more loaded with oxyd, and an acid ſolution.

Theſe, and many other facts which might be adduced, illuſtrate the general law of decompoſition by precipitation, and the conſtant tendency of metallic ſalts to divide into two compounds, each conſiſting of both the conſtituents of the ſalt but diſtributed in unequal proportions. Theſe phenomena are rendered ſtill more complex by the addition of new ſubſtances, moſt of which being deſcribed under the reſpective metals, a repetition in this place would be needleſs.

The ſecond ſpecies of metallic precipitates are thoſe in which the metal appears in its reguline form. This takes place when one metal is precipitated by another, as when a piece of iron is immerſed in a ſolution of copper, and alſo when phoſphorus is kept for ſome time in certain metallic ſolutions.

Before the diſcovery of oxygen, and of the oxydation of metals being neceſſary to their ſolution in acids, the precipitation of one metal by another was ſuppoſed to be produced by ſimple elective attraction, and the reſpective affinities of the metals for the acids was put down in the order of the precipitations which they produced. But this explanation though true in general, does not explain a number of apparent anomalies in metallic precipitation, ſo that we muſt take into conſideration the force of other agents and other affinities.

The order of the precipitation of one metal by another is the following, among thoſe that have been the moſt accurately examined, viz. zinc,[a] iron, lead, tin, copper, ſilver, mercury, gold; that is to ſay, zinc precipitates all the other metals; iron precipitates all but zinc; lead all but zinc and iron; &c.

But ſometimes the precipitation fails with ſolutions in one acid, though it ſucceeds with others; thus zinc ſeparates iron in the metallic ſtate from muriat of iron, but only as an oxyd from the nitrat. A ſmall exceſs of acid is neceſſary to begin the proceſs in all caſes.

During this operation the following affinities muſt act, namely, that of the precipitant (or metal by which the ſeparation is effected) for the oxygen of the metal already diſſolved; that of the oxyd thus produced, for the acid of the ſolution; and to this Berthollet adds, that of the two metals for each other when in the reguline ſtate. The ſum of theſe affinities muſt overcome that which exiſts between the conſtituent parts of the metallic ſalt intended to be decompoſed.[b]

It is poſſible therefore that no precipitation may take place even when the metal added has a greater affinity for oxygen than that already diſſolved, if the oxyd of the former metal has a leſs affinity for the acid than the oxyd of the latter has. And on the other hand a precipitation may be effected even if the precipitant has leſs affinity for oxygen than the metal already diſſolved, provided its oxyd has a greater affinity for the acid. In this latter caſe however there muſt be a conſiderable exceſs of acid preſent in order to begin the oxydation of the precipitant. Thus, again, it is explained why a precipitation will take place with the ſolution in one acid, and not in another, ſince the acids themſelves differ conſiderably in their affinity for the ſame metallic oxyd, ſo that in the firſt caſe, this affinity may ſurpaſs that of the ſame acid for the metallic oxyd already diſſolved, and in the ſecond may fall ſhort of it.

Still however (as Berthollet remarks) if the only active affinities in theſe caſes were thoſe of the metals for oxygen and the oxyds for acids, it is not probable that the reduction of the metal whoſe affinities were the weakeſt, would be complete, but in all probability there would be only an unequal partition of the acid and oxygen, ſo as to produce the *more* oxygenated ſalts of one metal, and the *leſs* oxygenated ſalts of the other metal, which would be agreeable to the uſual mode of action in ſimilar caſes. Hence it becomes neceſſary to recur to the well-known affinity which exiſts between the metals themſelves, and many facts ſhew that this is concerned in theſe proceſſes.

For example when a plate of poliſhed copper is dipped into a ſolution of nitrated mercury, it is inſtantly whitened by the mercury precipitated upon its ſurface, but this metal is not merely depoſited upon the copper, but amalgamated with it, ſo that it cannot be ſcraped or rubbed off, but can only be ſeparated by fire. Here then the affinity of the mercury for the copper muſt act forcibly in cauſing its ſeparation from the nitric acid which held it in ſolution. In like manner when copper is immerſed in a ſolution of ſilver, the precipitated metal is not pure ſilver, but an alloy, containing a very ſmall portion of copper. As this mutual affinity exiſting between the metals varies according to the metal employed, this alſo explains why iron (for example) precipitates ſilver from its ſolution with much more difficulty than copper, though iron has a much ſtronger affinity for oxygen than copper (as is proved by the precipitation of copper by iron) for the affinity between ſilver and copper is much ſtronger than between ſilver and iron.

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[a] Bergman.

[b] Vauquelin, An. Chim. xxviii. p. 40.

As then metallic precipitates are in fact alloys (though often with ſuch a ſmall proportion of the precipitant as to be ſcarcely ſenſible) it is neceſſary that the combination of the metals muſt firſt be made when both are in ſolution, for we can conceive of no other method by which two ſolid metals (copper and iron, for example) ſhould be alloyed in a common temperature. The whole proceſs therefore muſt be the following, taking the above metals as inſtances; a portion of the iron muſt firſt be oxydated and diſſolve in the acid, and by this it diſoxydates and precipitates in the metallic form an equivalent portion of the copper, during which time the diſſolved iron muſt divide itſelf into two, very unequal portions, of which by far the largeſt part remains in ſolution, but the remainder muſt return to the metallic ſtate to unite with the copper and to be precipitated along with it. This complicated action muſt take place even from the firſt, for how elſe can the union of the two metals be accounted for? and ſtill leſs can it be explained without this ſuppoſition, as the precipitation proceeds, when the ſurface in contact with every freſh ſtratum of precipitate is no longer iron, but an alloy of copper and iron almoſt approaching to pure copper.

This leads us alſo to conſider what is the affinity that determines the place to which the precipitates attach themſelves. In the firſt inſtance, that is, when a ſurface of pure iron is expoſed to the cupreous ſolution, the precipitate may be ſuppoſed to attach itſelf to the iron rather than to fall down looſe in the veſſel on account of the affinity exiſting between iron and copper alloyed with a little iron; but after the ſurface of the iron bar is covered, each ſucceſſive ſtratum of precipitate attaches itſelf not to the iron (for this is covered) but to the ſurface of the precipitate already formed, that is to ſay, to a ſubſtance of exactly the ſame compoſition as itſelf. In this latter caſe therefore, the ſame kind of affinity acts as when a ſaline ſolution during cryſtallization depoſits its cryſtals on the portion of ſalt already ſeparated, rather than on a naked ſurface. The adheſion in this inſtance, however, is very ſlight, and readily broken. The proportion of the precipitant which enters into the alloy is probably greater in the firſt ſtratum of precipitate than in the ſubſequent ones; thus when copper is ſeparated by iron, the part immediately in contact with the iron is viſibly browner than the reſt, owing probably to a larger admixture of iron.

It has been mentioned that phoſphorus will ſeperate ſome metals from their ſolutions in the reguline ſtate. Theſe are particularly gold, ſilver, mercury, and copper. If a ſtick of clean newly-melted phoſphorus is immerſed in an acidulated ſolution of ſulphat of copper, in a day or two it becomes beautifully ſpangled with little knobs of bright metallic copper, which gradually increaſe to a thick cruſt, after which if the ſtick is put into boiling water, the phoſphorus will melt out, and leave a delicate hollow cylinder of copper. In this caſe however, as in the former, the precipitate is not pure copper, but an alloy of copper with phoſphorus, or a phoſphuret, in which however the quantity of phoſphorus is extremely ſmall, and the ſolution contains phoſphoric acid. When phoſphorus is introduced into a ſolution of mercury, only part of this metal aſſumes the metallic form, and the reſt is oxyd combined with phoſphorus and phoſphoric acid.

From what has been obſerved above it is obvious that the method of recovering one metal from its ſolution by the addition of another, which is ſo often reſorted to in analyſis, requires conſiderable precaution, is liable to many inaccuracies, and can only be employed with propriety in certain caſes. The circumſtances which forbid its uſe, or render it inconvenient, are the following.[a] 1ſt. Where the ſalt formed by the union of the precipitant in the acid is inſoluble in water, and will mix with the precipitated metal from which it cannot be readily ſeparated, as when ſulphat of copper is decompoſed by lead, antimony, or mercury, for the ſulphats of theſe metals are little ſoluble in water: or 2ndly, where the newly formed ſalt would be decompoſed by the water, as when any nitrated ſolution is precipitated by biſmuth: or 3dly, when the whole of the new oxyd formed by the transfer of oxygen from the precipitated metal to the precipitant cannot be diſſolved by the acid preſent, as when nitrat of copper is decompoſed by lead, in which caſe the precipitate will be very *largely* alloyed by the precipitant; or 4thly, when the affinities of the precipitant are ſuch as more eaſily to decompoſe the acid than to abſorb the oxygen of the metal already diſſolved, as when nitrat of copper is decompoſed by zinc, in which caſe the precipitate is partly reguline and partly oxydated; and 5thly, where the affinities between the two metals are ſo ſtrong that the precipitate is *largely* alloyed with the precipitant, as when a ſolution of ſilver is decompoſed by mercury.

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[a] Vauquelin.

Of theſe five caſes, the 3d is probably that which much more contributes to produce a large alloy of the precipitated metal than even the affinity exiſting between the two metals; thus Vauquelin found that 50 grs. of copper, diſſolved in nitric acid even with exceſs of acid required no leſs than 216 grs. of lead for its compleat ſeparation, and the precipitate, inſtead of weighing only 50 grs. amounted to 128 grs. of which therefore 50 were copper, and 78 were lead. Yet theſe two metals have but little affinity for each other. This inconvenience is corrected, though not entirely removed by adding a conſiderable exceſs of acid.

PRECIPITATE, *white*,
PRECIPITATE, *red*,
PRECIPITATE, *per ſe*
} are all oxyds or ſalts of MERCURY, *which ſee.*

PRECIPITATE, *purple*, *of Caſſius*. See GOLD.

PREHNITE.

Its colour is pale green, either whitiſh, greyiſh, or yellowiſh. It occurs generally in maſs, but is ſometimes cryſtallized in oblique quadrilateral priſms.

The cryſtals are either ſingle or aggregated; and are ſmall or middle ſized. Externally they are ſmooth and ſhining; internally they have a gliſtening pearly luſtre.

The fracture is foliated or divergingly radiated; the fragments are indeterminately angular and wedge-ſhaped. It is tranſlucent, but ſometimes is nearly tranſparent. It is ſomewhat harder than glaſs, and is eaſily frangible. Sp. gr. 2.6 to 2.94.

Before the blowpipe it boils and melts into a yellowiſh brown enamel, but it does not become gelatinous with acids, in which reſpect it differs from zeolite with which it has otherwiſe a conſiderable reſemblance.

The prehnite of the Cape of Good Hope has been analyſed by Klaproth, and that of France by Haſſenfratz, with the following reſults.

Klapr.		Haſſ.	
43.83	—	50.	Silex.
30.33	—	20.4	Alumine.
18.33	—	23.3	Lime.
5.66	—	4.9	Oxyd of iron.
1.83	—	0.9	Water.
0.	—	0.5	Magneſia.
99.98		100.0	

It occurs in veins in primitive ſlaty grunſtein, alſo in rocks of the moſt recent floetz trap formation. It was firſt diſcovered by Col. Prehn at the Cape of Good Hope, and has ſince been found in Dauphiné in France, in the valley of Faſſa in the Tyrol, alſo in Arthur's Seat near Edinburgh, and in other parts of Scotland.

PRINCE'S METAL. See COPPER, Alloys of.

PROBIERSTEIN. See KIESELSCHIEFER.

PROOF BOTTLE, an article of chemical apparatus; for an account of which ſee the Appendix.

PRUSSIAN BLUE, *Berlinerblau*, Germ.

PRUSSIC ACID, *Blauſaure*, Germ.

Pruſſian Blue is a pigment of a beautiful dark blue colour which was diſcovered about the year 1710 by a chemiſt of Berlin of the name of Dieſbach by the accidental mixture of a ſolution of vitriol of iron with an alkali which had been highly impregnated with animal matter. This diſcovery led to the preparation of this ſubſtance as a pigment, but the preciſe proceſs was long kept ſecret till it was made known in the Philoſophical Tranſactions for 1724, by Dr. Woodward. This has been adopted with ſome variations by ſucceeding chemiſts.

The proceſs of preparing Pruſſian blue as given by Macquer, in his valuable memoir on the ſubject, is the following: prepare a quantity of bullock's blood by moderate drying, till it is reduced to powder, mix four ounces of this with as much carbonat of potaſh (made by calcining equal parts of nitre and tartar) put the whole in a covered crucible with a ſmall hole at the top, and calcine it in a moderate fire till no more ſmoke or flame iſſues through the hole, at which time the maſs will be black and carbonaceous; then raiſe the heat till the whole is moderately red, and remove it from the fire. Then take out the contents of the crucible, and boil them for half an hour with two quarts of water and filter the liquor. Add to this immediately a ſolution of two ounces of vitriol of iron and eight ounces of alum in two quarts of boiling water, which will cauſe a great effervescence, and a copious depoſit of a blue-green precipitate. Separate this latter by filtration, and add to it a few ounces of muriatic acid with much ſtirring, which will immediately change the colour from blue-green to a deep blue. The quantity of acid is to be determined by the effect produced. The precipitate after ſtanding for a day is then thoroughly waſhed and ſlowly dried, and is the Pruſſian blue.

This with ſome variations in the proportions of ingredients and in the exact manipulation is ſaid to be the uſual way of preparing this pigment in manufacture, and will always ſucceed to a certain degree. Neverthelefs ſeveral chemiſts who have exactly followed it in the large way for the purpoſe of ſale, have been diſappointed in the quantity yielded, and have not always ſucceeded in the quality of the article, ſo that it is probable that there are ſome particulars in the manipulation, &c. which are only known to the manufacturers.

It is immaterial whether the alkali uſed in the calcination with blood is cauſtic or carbonated, ſo that the latter is always employed. Any good pearlaſh will anſwer the purpoſe, and it is better to uſe from two to three times as much dried blood.

This proceſs conſiſts eſſentially of two operations, one, the impregnation of the alkali with that peculiar principle contained in the blood (and in moſt other animal matters) which gives the power of ſtriking a blue colour with iron, and is called the *Pruſſic Acid*; and the other, of partially decompoſing this alkaline pruſſiat by the mixed ſulphats of iron and alumine, and uniting thereto the oxyd of iron and the alumine ſeparated by the alkali. The uſe of the muriatic acid in finiſhing the proceſs, appears to be (as we ſhall preſently mention) chiefly to diſſolve out the ſuperfluous oxyd of iron, and bring the whole to that fine blue colour for which this ſubſtance is ſo much admired.

The firſt lixivium of the alkali after being calcined with the blood, was formerly termed *Phlogiſticated Alkali.*

Pruſſian blue as commonly prepared is a very compounded ſubſtance, conſiſting of the Pruſſic acid, of oxyd of iron, generally of potaſh and of alumine, but the two laſt of theſe are in no degree eſſential to the Pruſſian blue, chemically ſpeaking, as the ſolution of ſulphat of iron alone will produce it of as fine a colour, and as perfect a chemical compound. The alumine may be entirely put out of the queſtion, as the ſubject is ſufficiently complicated without it, and its uſe ſeems chiefly to be to give a body to the colour (as in preparing the alum lakes) and perhaps to render it more convenient for the painter's uſe.

The inveſtigation of the properties of this moſt ſingular ſubſtance, is perhaps, one of the moſt perplexing in chemiſtry, as the ſubſtance called Pruſſic acid, is quite *ſui generis*, and exerciſes affinities which are remarkably complicated, and ſcarcely to be explained by analogy with any other known body.

Macquer in a very elaborate enquiry explained ſome of the moſt important combinations of this ſubſtance, but little was known concerning the intimate nature of Pruſſic acid, before the moſt admirable reſearches of Scheele, who, with an intelligence and ſagacity peculiar to himſelf, deviſed and performed a number of experiments on this ſingular ſubſtance which immediately explained many of its moſt important properties, and opened the way to the fine experiments of Berthollet and ſucceeding chemiſts.

Pruſſian blue is inſoluble in water and in acids. Though the lixivium from which it is formed is made at a red heat, the Pruſſian blue itſelf is entirely decompoſed at this temperature giving out carbonated hydrogen and carbonic acid, and the oxyd of iron and alkali are left behind.

We cannot follow a better order in our account of this ſingular ſubſtance, than by firſt giving a ſhort abſtract of the experiments of the illuſtrious Swediſh chemiſt.[a] He firſt examined the *lixivium ſanguinis*, or liquor obtained by diſſolving in water all the ſoluble part of the maſs of calcined blood and alkali, before the ſolution of vitriol of iron is added. This lixivium, compoſed of Pruſſic acid and potaſh, ſoon loſes its power of forming Pruſſian blue with ſolution of iron when it has been expoſed to air. This the author conjectured might be owing to the carbonic acid of the atmoſphere, which ſuppoſition was confirmed by confining a little of it in an atmoſphere of fixed air for a day, after which the oxyd of iron produced by adding vitriol of iron to it, was again ſoluble in acids, and was therefore not pruſſiated iron, ſo that the lixivium had been converted into ſimple carbonated potaſh. This was owing to the carbonic acid confined with it having united with the potaſh, and diſplaced the pruſſic acid which was volatilized. The Pruſſic acid therefore is ſhewn to have leſs affinity for alkalies than even the carbonic, and to aſſume the gaſeous form when expelled from its baſe. Some of the *lixivium ſanguinis* was then firſt mixed with a little vitriolated iron, which turned it yellow, and afterwards expoſed to carbonic acid as in the former caſe, but now the pruſſic acid was not expelled, ſo that it ſtill was able to form a perfect Pruſſian blue by a further addition of vitriolated iron, and ſubſequent waſhing with muriatic acid. Another portion of the lixivium was boiled for ſome minutes with the green oxyd produced by decompoſing vitriolated iron by an alkali added when ſtill wet, and this was expoſed to the air for ſome time, but it ſtill retained its power of forming Pruſſian blue. On the other hand, when another portion was boiled with the fully oxydated calx of iron from a nitrous ſolution, none of the metal was taken up, and the lixivium then loſt its Pruſſic acid by ſhort expoſure to air. Hence the important fact is proved, that the preſence of iron is neceſſary to give fixity to the pruſſic acid though already combined with an alkali, and to prevent it from being ſpeedily diſſipated by the weakeſt agents, even by the carbonic acid of the air.

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[a] Scheele's Eſſays on Pruſſian Blue.

To detect more fully the volatilization of the pruſſic acid when not detained by iron, this chemiſt ſuſpended over the ſimple lixivium ſome paper firſt dipped in vitriolated iron, and then pencilled with alkali, and after two hours expoſure on dropping muriatic acid on the ſpot, it became covered with the fineſt Pruſſian blue.

Theſe experiments led to the attempt to obtain the pruſſic acid perfectly free from all combination. For this purpoſe the lixivium ſanguinis (without iron) was ſuperſaturated with ſulphuric acid, and diſtilled from a glaſs retort with a gentle heat. When one-third had paſſed over into the receiver it was examined. It was a watery liquor with a peculiar taſte and ſmell like peach-flowers, but it had detained only a part of the pruſſic acid expelled, as the air in and around the veſſels was ſtrongly impregnated with the volatile acid, and turned paper blue that had been dipped in an iron ſolution and alkali, as in the caſe already mentioned. But enough of the acid was detained by the water to be clearly detected by the iron teſt. The pruſſic acid of this aqueous ſolution was ſtill more volatile than in the lixivium, as might be expected, and was entirely diſſipated by a ſhort expoſure to air. In diſtilling this liquor the proceſs may be ſtopped after about a third has come over, as this contains all the pruſſic acid. It alſo holds a little of the ſulphuric acid (as detected by precipitating a barytic ſolution) ſo as to redden litmus, which the pure pruſſic acid will not do.

It was then attempted to procure this acid from the pruſſian blue itſelf, or rather from that yellow cryſtallized ſalt obtained by digeſting the blue with cauſtic alkali in the way that will be afterwards deſcribed. This is a triple ſalt compoſed of pruſſic acid, potaſh, and oxyd of iron, and therefore one in which the iron ſerves as a bond of union between the acid and alkali. It contains leſs oxyd of iron than the pruſſian blue, and hence whenever any portion of its pruſſic acid is abſtracted, the remainder is liable to paſs into the ſtate of pruſſian blue. This ſalt ſhould be termed in ſtrictneſs *pruſſiat of potaſh and iron*, to diſtinguiſh it from the ſimple pruſſiat of potaſh, ſuch as exiſts in the *lixivium ſanguinis*, but as the latter is ſeldom prepared, the triple pruſſiat above mentioned has got the name ſimply of *pruſſiat of potaſh*, which we ſhall here retain.

To obtain the acid from this ſalt, an ounce of it was diſſolved in four parts of water, to which were added three drachms of ſulphuric acid, and the whole was put into a retort with a cloſe receiver. As ſoon as the maſs began to boil, it grew thick, and a great quantity of pruſſian blue was ſeparated. The diſtillation was continued till an ounce of liquor had paſſed over, which proved to be pure pruſſic acid ſimply diſſolved in water, and all the veſſels were alſo full of the vaporized pruſſic acid. The blue maſs in the retort was then filtered, by which a clear liquor (which contained merely ſulphat of potaſh) was ſeparated, and the pruſſian blue remained on the filter. This blue was again boiled with cauſtic potaſh, to convert it into pruſſiat of potaſh, and diſtilled with ſulphuric acid as before, during which preciſely the ſame phenomena took place as at firſt, pruſſiated water and gas were diſtilled, and ſome pruſſian blue and ſulphat of potaſh were formed. The ſame was repeated a third time, with ſimilar appearances, only that the quantity of regenerated blue was now very minute, ſo that it appears that by a ſucceſſion of theſe operations all the pruſſic acid may be expelled from the pruſſiat.

But this method of obtaining pure pruſſic acid being troubleſome and imperfect, (owing to the conſtant regeneration of pruſſian blue) the ſame excellent chemiſt diſcovered a ſtill better way, and which is the one now followed. When pruſſiat of potaſh or pruſſian blue is digeſted with any oxyd of mercury, the pruſſic acid unites with this metal, and a ſoluble pruſſiat of mercury is formed which cannot be decompoſed ſingly by acids or alkalies, and may be brought to cryſtallize by evaporation. When this pruſſiat is digeſted with metallic iron the firſt action of the iron is to deprive the mercury of its oxygen, and precipitate it viſibly in the metallic ſtate; and the pruſſic acid is ſet at liberty. This however would immediately unite with the iron if it were not prevented by the preſence of a ſtronger acid, for which the ſulphuric (or indeed any other) may be added. Then on applying heat, the diſengaged pruſſic acid riſes in diſtillation with the firſt water that comes over, and may be collected. The exact proceſs of Scheele is the following: to two ounces of pruſſian blue mixed with one ounce of red mercurial precipitate, 6 oz. of water were added, and the whole was boiled for ſome minutes with conſtant agitation, when the blue colour entirely diſappeared, and the maſs became of a yellowiſh grey. It was then filtered, and the maſs on the filter edulcorated with a little hot water which was added to the clear liquor. This, which had a ſtrong mercurial taſte and was pure pruſſiat of mercury, was then poured upon 1½ oz. of clean iron filings, to which were added 3 drams of ſtrong ſulphuric acid. The whole was well agitated, and in a few minutes it was turned quite black by the reduced quickſilver, and at the ſame time loſt its mercurial taſte and acquired the peculiar peach-flower ſmell of free pruſſic acid. The liquor, poured off from the mercury that had ſubſided, was then put into a retort, and a fourth part of it was diſtilled over into a well luted receiver, and this liquor was now aqueous pruſſic acid, with no other admixture than that of a little ſulphuric acid which had riſen along with it. This was got rid of by mixing it with a little chalk, and a ſecond diſtillation. Probably barytic water would be preferable, as every diſtillation volatilizes and deſtroys a portion of the pruſſic acid.

There appears at firſt ſight a contradiction in the order of affinities between pruſſic acid, iron, and mercury reſpectively, when it is found on the one hand that oxyd of mercury decompoſes pruſſian blue, and takes this acid from the iron and potaſh with which it is united; and on the other hand when iron filings again compleatly decompoſe pruſſiat of mercury. Berthollet explains this apparent contradiction by alledging that the *oxyd* of mercury has a ſtronger affinity for this acid than the *oxyd* of iron, even combined with potaſh, and hence any mercurial oxyd or ſalt will decompoſe pruſſian blue and give a pure pruſſiated mercury; but on the other hand iron has a greater affinity for oxygen than mercury has, and hence *metallic* iron decompoſes the oxyd of mercury exiſting in the pruſſiat, and the mercury, now brought to the metallic ſtate, ſeparates from the ſolution.

We ſhall now deſcribe the properties of this acid and its compoſition, and afterwards proceed to its combinations, in which it will be neceſſary in ſome degree to return to thoſe pruſſiats of iron and potaſh which have been already partially deſcribed.

THE PRUSSIC ACID, (the preparation of which in a liquid form has been already deſcribed) has a ſweetiſh and acrid taſte, and a ſmell reſembling that of peach-flowers or bitter almonds; nor is this latter circumſtance a mere coincidence, ſince this acid is actually found in many parts of vegetables. It is ſtrongly poiſonous. It does not redden vegetable blues, and hence, as well as from the abſence of ſourneſs of taſte, it is very doubtful how far it ought to be entitled to the name of an acid, though from its property of neutralizing alkalies and forming cryſtallizable ſalts with them, and with metallic oxyds, it is more conveniently claſſed among theſe bodies. It does not appear to contain any oxygen. It precipitates ſulphurets, and curdles ſoap. It is extremely volatile when ſimply united with water, or with an alkaline baſe ſingly, and is expelled from the latter by every known acid, and even by light, and by a moderate heat. It cannot be cryſtallized.

It has no action upon metals, but unites with their oxyds, forming combinations for the moſt part inſoluble, and not eaſily decompoſable by other acids. It has the greateſt tendency to form triple ſalts when in contact with an alkali and a metallic baſe, and it adheres to the alkalies and earths with much more force when alſo united to a metallic oxyd (particularly of iron) than when only in ſingle combination. It is totally decompoſed by oxymuriatic acid. The double and triple ſalts formed by this acid with the different baſes will be preſently deſcribed, but we ſhall firſt mention the experiments of

Scheele, Berthollet, and others, which lead to an explanation of the nature of this ſingular ſubſtance.

Thoſe of Scheele were the following (among many others of leſs importance).

Some pure pruſſian blue was prepared and diſtilled *per ſe* in a retort, to which was attached a receiver containing a little water. The fire was urged till the retort was red-hot. The water in the receiver contained ſome undecompoſed pruſſic acid, and ammonia, and the air of the veſſel was impregnated with the volatile acid, and with carbonic acid gas. The maſs that remained in the retort was black and magnetical. Hence ammonia appeared to be one of the conſtituents of pruſſic acid, and the other the author was at firſt diſpoſed to believe to be an animal oil. He then endeavoured to compoſe pruſſian blue by uniting ammonia with ſome oily matter by diſtillation of this alkali with fat, lard, oil of turpentine, &c. but to no purpoſe. This led to the further conjecture that it was the carbonaceous part of the oil alone that was eſſential, which was confirmed by the following experiments: two crucibles were filled with a mixture of charcoal powder and alkali of tartar, and kept for a quarter of an hour at a red-heat. The contents of one were then thrown into water, but into the other ſome dry muriated ammonia was ſtirred in, and heated for a minute or two till no more ammoniacal vapours were given out. This was then lixiviated with water. On trying the lixivium from the firſt crucible, with vitriol of iron, and acids, ſcarcely any ſenſible quantity of pruſſian blue was obtained: but the ſecond gave it in abundance. In another experiment, plumbago was ſubſtituted to the charcoal, and after calcination with potaſh and ſal-ammoniac, it yielded pruſſian blue. From theſe intereſting experiments it appears that the pruſſic acid is generated by ſome peculiar action of charcoal on ammonia, aſſiſted, doubtleſs, by the operation of potaſh, or in other words, that it is, probably, ammonia intimately combined with carbon. Hence when pruſſian blue is mixed with ſix times its weight of black oxyd of mangaueſe and diſtilled, nothing but carbonated ammonia comes over into the receiver.

Berthollet purſued theſe ingenious reſearches, calling in the aſſiſtance of another and moſt powerful agent, the oxymuriatic acid. If this acid is mixed with liquid pruſſic acid prepared in the way given by Scheele, the oxymuriatic acid loſes its peculiar ſuffocating ſmell, and becomes common muriatic acid, whilſt the liquor acquires a much more pungent odour, and appears to have become more volatile, and its affinity for alkalies to be leſſened. In this ſtate the precipitate which it forms with the ſolutions of iron, is at firſt green, but turns blue by the action of light, or by ſulphureous acid, that is (probably) by loſing a part of its oxygen. When ſulphat of iron is mixed with oxymuriatic acid, and pruſſiat of potaſh is added, the green precipitate firſt formed is rediſſolved, but may be changed to the common inſoluble blue pruſſiat by ſimple ſulphat of iron, or iron filings, or ſulphureous acid. If pruſſic acid is fully impregnated with the oxymuriatic and then expoſed to the light, its properties as pruſſic acid are deſtroyed, and new ones are acquired. It now no longer combines with iron, and aſſumes quite a different and very peculiar ſmell, and when ſhaken with water, a great part collects at the bottom on ſtanding for a few ſeconds, and reſembles in appearance an eſſential oil. This ſingular ſubſtance however is not inflammable, but at a moderate increaſe of heat it reſolves into a vapour immiſcible with water. If left to itſelf, in time it cryſtallizes, but the nature of theſe cryſtals is not known.

Though pruſſic acid at firſt contains no ammonia, as ſuch, (at leaſt not in a ſtate to be diſengaged by lime or the alkalies, as is the caſe with all the known ammoniacal mixtures) yet when it has been brought by oxymuriatic acid to that point at which it precipitates a *green* pruſſiat of iron inſtead of a blue, and fixed alkalies or lime are added, it *now* gives the volatile alkali in abundance, and loſes its peculiar peach flower ſmell. At the ſame time it effervesces with the ſtronger acids, and carbonic acid is diſengaged. Hence it ſeems the moſt probable ſuppoſition that pruſſic acid contains neither carbonic acid nor ammonia ready formed, but the elements of theſe, (with the exception of oxygen) or in other words, that pruſſic acid is a combination of carbon with hydrogen and azot.

The method indicated by Scheele of compoſing pruſſic acid, by heating together ammonia and charcoal, was repeated by Clouet[a] in a different manner, that is, by paſſing ammoniacal vapour through red-hot charcoal. This vapour was diſengaged from a mixture of lime and ſal-ammoniac in an earthen retort, the neck of which was luted into a porcelain tube containing charcoal, and lying acroſs a ſmall furnace. To the oppoſite end of the tube was luted a tubulated balloon, which communicated with two other balloons in ſucceſſion, the firſt of which contained a ſolution of ſulphat of iron, the ſecond, ſome of the ſame ſolution acidulated, and the third, an acid nitrous ſolution of iron. When the charcoal was red-hot, the ammonia was paſſed through it, and the gas in paſſing through the three balloons, produced a large quantity of Pruſſian blue in the firſt (which contained neutral ſulphat of iron) but none in the ſecond or in the third. In another experiment the firſt balloon was filled before the operation with ſulphuric acid, largely diluted with water, the ſecond contained diſtilled water, and the third, cauſtic ſoda in dilute ſolution. When the operation was finiſhed, the firſt balloon contained ſulphat of ammonia (owing to the paſſage of ſome undecompoſed ammonia) and alſo ſome pruſſic acid, ſo as to give the blue pruſſiat on adding a ſolution of iron. The ſecond appeared to hold pure pruſſic acid, and gave Pruſſian blue on adding a ſolution of iron, and along with it ſome alkali. In the third, the ſoda was found combined with a large quantity of pruſſic acid.

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[a] An. Chim. tom. xi.

This experiment was repeated by Bonjour,[b] who on adding potaſh and oxyd of iron to one of the balloons, obtained in it after the diſtillation a ſenſible quantity of cryſtallized pruſſiat of potaſh.

The pruſſic acid often makes its appearance (and is detected either by the peach-flower ſmell or by the blue precipitate which it forms with ſolutions of iron) during a variety of decompoſing operations on animal ſubſtances either ſpontaneous or artificial. Thus Vauquelin found it produced by the action of nitric acid on ſerum, and Fourcroy and others have detected it as an occaſional product (though rare) of animal putrefaction.

This acid is alſo contained in the vegetable kingdom in ſmall quantity, in thoſe ſubſtances where the ſmell would indicate it to be, that is, in bitter almonds, peach flowers, in the leaves of the lauro-ceraſus, &c. As theſe contain a poiſonous principle, it has been conjectured with ſome probability that it may reſide in the pruſſic acid, which is itſelf highly deleterious.

M. Schrader[c] detected this acid in theſe vegetable ſubſtances by adding lime to the concentrated infuſion or diſtilled water, then applying a ſolution of iron and acid. Vauquelin alſo[d] obtained a notable quantity of the acid in the diſtilled water from the kernels of apricots, and that of bitter almonds. Theſe waters were mixed with a ſolution of iron, then precipitated entirely by ammonia, and after ſtirring the mixture and repoſe for ſome hours, ſulphuric acid was added, which diſſolved the exceſs of oxyd of iron, and left an inſoluble blue-green precipitate, which retained its colour for ſome days, but immediately became blue in the heat of boiling water. The alkalies took away the blue colour and changed it to yellow, as they do the common blue pruſſiat of iron. As the heat employed here was not ſuperior to that of boiling water, it appears more than probable that the pruſſic acid was merely expelled from the almond and other kernels by diſtillation, and not formed in the proceſs, which therefore will entitle the pruſſic acid to be conſidered as one of the immediate vegetable principles.

Prussiats. We ſhall now deſcribe more fully the more important combinations of this acid with the various baſes.

Pruſſiat of Iron. This ſalt cannot be made by the direct combination of the pruſſic acid and iron, but is always the reſult of the decompoſition of the ſolution of iron in another acid. When the pure pruſſic acid is added to any ſolution of this metal, the pruſſiat of iron thus formed is at firſt green, and is ſoluble in acids, hence much of it, and often the whole, remains in the ſolution, and no precipitate occurs. But on expoſure to the rays of light, or to ſulphureous acid, or if metallic iron is added to the ſolution, the colour becomes blue, and the pruſſiat, which is now no longer ſoluble in acids, falls down. Hence it would appear that pure *blue pruſſiat of iron* (which may be diſtinguiſhed from *Pruſſian blue* by containing nothing but pruſſic acid and oxyd of iron) contains the metal in a leſs oxygenated ſtate than in the green ſolution.

Another ſimple pruſſiat of iron has been noticed by Berthollet. When an alkali is digeſted with blue pruſſiat, a diviſion of its conſtituent parts takes place;[e] the alkali diſſolves out the greater part of the pruſſic acid, and a ſmaller part of the oxyd of iron, and theſe three ſubſtances, when the ſolution is evaporated, unite to form that triple ſalt, the *pruſſiat of potaſh with iron*, which is commonly termed ſimply *pruſſiat of potaſh*, and which will be preſently deſcribed. The remaining and inſoluble part of the blue pruſſiat, now conſiſts of pruſſic acid, with an exceſs of oxyd of iron, and is of a yellow colour bordering on red. It may be termed with propriety the *ſub-pruſſiat of iron*, but though it always contains more oxyd, or (what is the ſame thing) leſs acid than the blue pruſſiat, the preciſe proportion of its conſtituent parts is found to vary conſiderably, whereas thoſe of the blue pruſſiat are much more conſtant. When any acid is poured on this ſub-pruſſiat, it diſſolves the exceſs of oxyd, and immediately brings it to the ſtate of blue pruſſiat, which again may be decompoſed by alkalies as at firſt, and another but ſmaller quantity of ſub-pruſſiat is left; and thus by ſucceſſive applications of acid and alkali the whole may be decompoſed.

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[b] Journ. de l'Ecole Polytechnique 3d Cahier. [c] Journ. de Phyſ. tom 56. [d] Ann. Chim. tom. 45. [e] Mem. de l'Acad. 1787.

It has been mentioned that a blue pruſſiat may be made, ſimply by adding pruſſic acid to a ſolution of iron, and expoſure to light. This therefore can contain nothing but pruſſic acid and oxyd of iron, probably in proportions which vary but little, if at all. But when that pruſſiat is prepared in the uſual way, by adding pruſſiat of potaſh to the ſulphat or any other ſalt of iron, the blue precipitate always carries down with it a portion of alkali, with which it firmly unites, ſo as to render the alkali inſoluble in acids or in water. Hence it is that though the actual quantity of alkali in the pruſſiat of potaſh is more than ſufficient to ſaturate the acid of the iron ſolution, the latter always remains acidulous after the blue precipitate has ſubſided.[f] This will explain the great weight of ſuch precipitates compared with the quantity of metallic oxyd contained in the ſolution which has been decompoſed.

Beſides the ſpecies of pruſſiats of iron already mentioned, that is, the blue and the yellow, or ſub-pruſſiat, which differ in the proportions of oxyd of iron which they contain, another is deſcribed by Prouſt, the *white pruſſiat*, which is ſtated to have the ſame proportion of acid and iron as the blue pruſſiat, but in which the metal is in a much lower ſtate of oxydation. The method of procuring the white pruſſiat is the following:[g] take a ſolution of *green* ſulphat of iron, or that in which the metal is at the loweſt ſtate of oxydation (and which is prepared from the common ſulphat by adding iron filings, or tin, or ſulphuretted hydrogen, and has been deſcribed under the article Iron) add to it a ſolution of pure pruſſiat of potaſh, rather more than is ſufficient to decompoſe it, and cork the bottle immediately. A copious white precipitate falls down, which is the white pruſſiat of iron, and ſoon becomes green, but if the bottle remains corked this colour does not deepen, nor alter by expoſure to light. After ſtanding for ſome hours, it becomes covered by a yellow liquid, which is a mixture of pruſſiat and ſulphat of potaſh, together with a little of the white pruſſiat, which is held in ſolution, and hence if expoſed to the air it becomes blue, and a blue pruſſiat is precipitated.

The white pruſſiat therefore, according to this ingenious chemiſt, differs from the blue only in containing leſs oxygen, which it has a very ſtrong tendency to abſorb from the air, or from all bodies that yield this ſubſtance, and thus to paſs into the ſtate of blue pruſſiat. Thus the oxymuriatic acid effects this change immediately, the nitric acid more ſlowly. But the ſulphuric and muriatic acids have no effect. On the other hand, the de-oxygenating ſubſtances, ſuch as ſulphuretted hydrogen, have no effect on the white pruſſiat, but bring to this ſtate the blue pruſſiat when long kept in contact with it. The ſame change is produced when the blue pruſſiat is kept in water in a well-cloſed bottle, in contact with bits of iron or tin. Conformably with his theory concerning the ſalts of iron, Prouſt concludes therefore, that in the white pruſſiat the metal contains 27 *per cent.* of oxygen; in the blue, when fully oxygenated, it contains 48 *per cent.* and he ſuppoſes that there is no intermediate ſtate of oxygenation, except what may be produced by the mere mechanical mixture of one oxyd with another in any given maſs.

This however he ſuppoſes is actually the caſe for the moſt part with the white pruſſiat, that is to ſay, it ſcarcely ever can be obtained, or at leaſt preſerved, for any time perfectly white, but from the preſence of atmoſpherical air, or other ſources of oxygen, a ſmall and varying portion is always converted into the blue oxyd, and in mingling with the whole maſs, it gives thoſe different ſhades of blue-green which are obſerved.

Such is the theory given by Prouſt of the difference between theſe two pruſſiats, which however is called in queſtion by Berthollet,[h] on account of the great rapidity with which the blue pruſſiat is formed in various circumſtances where the operation of the external air can hardly be ſuppoſed to act. The facts given by Berthollet are the following: if a mixture of the green or leaſt oxydated ſulphat of iron be mixed with pruſſiat of potaſh, though the latter is in large proportion, the liquor retains the vitriolic taſte, ſhewing that the whole of the ſulphat of iron is not decompoſed, and the ſubſtance which Prouſt calls the white pruſſiat is precipitated; but if diſtilled water is added to the mixture it immediately becomes of a deep blue, with a greeniſh tinge. Muriatic acid gives it a deep blue colour, and ſo ſpeedily, that no ſenſible action of the atmoſpheric air can be ſuſpected.

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[f] Berthollet, Chem. Statics.

[g] Ann. Chim. tom. 23.

[h] Chem Statics.

Again, if ſome of the white pruſſiat be put into a flaſk filled with muriatic acid, and inſtantly corked, it becomes perfectly blue, and the ſame takes place with the ſulphureous and phoſphoreous acids. Alſo if white pruſſiat be formed in a glaſs, and ſulphuric acid poured down upon it, the whole becomes blue that is in the reach of the acid, whilſt the liquor at top remains colourleſs. Theſe three laſt experiments are directly in contradiction to Prouſt, who aſſerts that the acids which do not impart oxygen, ſuch as the ſulphuric and muriatic, do not change the white pruſſiat. Berthollet explains theſe phenomena in the following way: in experiments on the metallic ſolutions it is found that the oxyd of iron adheres much more ſtrongly to the ſulphuric acid when it is a little oxydated than when it is much ſo; therefore the *green* ſulphat is not decompoſed by pruſſiat of potaſh when both ſolutions are concentrated, but yet theſe two ſubſtances exerciſe a mutual action which ſimply ſeparates them from the ſmall quantity of water which they contain. If however this quantity is increaſed, the action of the ſulphuric acid on the oxyd is proportionably leſſened, and *then* the pruſſic acid begins to combine with the iron and produce the blue pruſſiat, which mixes with the white compound and colours it, but as the pruſſiat has an exceſs of oxyd of iron, the colour is greeniſh. Hence is explained the effect of ſimple dilution with water on the white maſs, which Prouſt ſuppoſes to ariſe from the atmoſpheric air that the water may contain. If beſides, an acid is added (of whatever kind it be, whether ſuch as is liable to yield oxygen, or to abſorb it) this combines with the alkali preſent in the white maſs, and thus increaſes the action of the pruſſic acid on the oxyd of iron, and enables it to decompoſe the ſulphat. This alſo is ſtill farther augmented, if the acid alſo imparts oxygen to the oxyd, inaſmuch as by ſo doing, it weakens the affinity between the oxyd and ſulphuric acid, and renders it more eaſily decompoſed by the pruſſic acid. Berthollet however acknowledges that there is ſome difference between the blue pruſſiats, according to their ſtate of oxydation, which gives different ſhades of blue, but he denies the exiſtence of the white pruſſiat as deſcribed by Prouſt.

From all that has hitherto been obſerved therefore we cannot reckon with certainty more than three pruſſiats of iron, viz. the green, blue, and yellow. In the two firſt the proportion of metal to pruſſic acid appears to be the ſame, but the green is the moſt oxydated, and is ſoluble in acids. The blue pruſſiat, which is the moſt known and the moſt intereſting, is inſoluble in water or in acids, but may be decompoſed by alkalies, and in the proceſs the *yellow* or *ſub-pruſſiat* is left, which contains an exceſs of metallic oxyd, probably in the ſame degree of oxydation as in the blue pruſſiat, and may be brought to the blue ſtate by any acid which ſimply diſſolves the exceſs of oxyd. Theſe pruſſiats however, and particularly the blue, are in general triple ſalts, owing to a ſmall quantity of alkali which they retain, but they muſt not on that account be confounded with the cryſtallized pruſſiat of potaſh and iron.

Pruſſiat of Mercury. The pruſſic acid exerciſes ſo ſtrong an action on the oxyd of mercury, that even corroſive muriat is decompoſed by Pruſſian blue, and all the oxyds of this metal do the ſame, as has been already obſerved when deſcribing the method of obtaining this acid pure. The pruſſiat of mercury duly evaporated cryſtallizes in tetrahedral priſms. It is the only ſimple combination of this acid and a metallic oxyd which will cryſtallize. When pruſſiated lime [i] (meaning the combination of pure pruſſic acid with lime, and not the triple ſalt formed by digeſting Pruſſian blue with lime, for this contains iron) is added to nitrated mercury, a *black* precipitate falls down, which is the mercury reduced, and therefore ſeparated from the pruſſic acid.

Pruſſiat of Silver. The pure pruſſic acid when added to nitrated ſilver, precipitates a white pruſſiat of ſilver. When this metal is previouſly ſeparated from its ſolution by carbonat of ſoda, this acid unites with it, and forms white pruſſiat as before, and expells the carbonic acid which it contains. If the pure pruſſiat of lime as above deſcribed is added to any ſolution of ſilver, it forms a white curdy precipitate. [k] If more of the liquor is added, the precipitate rediſſolves, and this ſolution cannot then be decompoſed by muriatic acid or muriat of ammonia, which is a ſingular anomaly. The precipitate itſelf is inſoluble in acids.

Pruſſiat of Copper. The pure pruſſic acid digeſted with the carbonated oxyd of copper effervesces and turns it of a faint lemon colour, but it does not alter the ſolutions of this metal. If the pure pruſſiat of lime is added to the ſulphat of copper it firſt precipitates a lemon-coloured pruſſiat of copper, which more of the liquor rediſſolves, and this ſolution is ſoluble in ammonia without turning it blue. If more of the ſulphat of copper is added, the precipitate likewiſe diſappears.

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[i] Scheele.

[k] Ibid.

Some acids diſſolve only a portion of this precipitate, and the remainder is white, but the muriatic acid diſſolves the whole.

The triple pruſſiats alſo, whether with an alkaline or earthy baſis, decompoſe compleatly all ſolutions of copper, and with more eaſe than the ſimple pruſſiat, as indeed is the caſe with all the other metallic ſolutions. The pruſſiat of copper thus prepared is of a beautiful bright-brown, which mixes well with oil, and in beauty and intenſity ſurpaſſes every brown paint now in uſe. It has been introduced into the arts by Mr. Hatchett.[1] He prefers the muriat of copper precipitated by pruſſiat of lime. It muſt be well waſhed with cold water after precipitation, and dried without heat.

This ſalt is however in fact a pruſſiat of copper and iron, for this acid appears to carry with it in all its combinations, except that of mercury, a certain, and even conſiderable, portion of oxyd of iron. As a proof of this, when this pruſſiat of copper is digeſted with an alkali, the triple *pruſſiat of potaſh and iron* is obtained, as will be preſently mentioned.

The other metallic pruſſiats are formed in a ſimilar way with the above, but are of little importance.

PRUSSIATED ALKALIES and EARTHS.

Of theſe by far the moſt important is the

Pruſſiat of potaſh. It has been already mentioned that though the *pure* pruſſic acid is capable of uniting with cauſtic potaſh to ſaturation, the affinity between the two is extremely weak, ſo that this acid is diſplaced even by the carbonic, hence when this ſolution is expoſed to the air, the alkali abſorbs carbonic acid, and the pruſſic is expelled and evaporates. But when a certain quantity of oxyd of iron is preſent the effect is very different, and a triple ſalt ſeparable by cryſtallization is formed, containing pruſſic acid, potaſh, and iron, to which the acid now adheres ſo ſtrongly, that no acid can expell it unleſs heat is employed, except the oxymuriatic, which decompoſes and deſtroys the pruſſic acid. This triple combination of pruſſic acid, oxyd of iron, and potaſh, is uſually termed ſimply *pruſſiat of potaſh*, which we ſhall here retain.

A great many experiments have been made by chemiſts to prepare this ſalt pure and of uniform compoſition, as in this ſtate it is a valuable chemical teſt, having the property of forming a precipitate with all the metallic ſolutions except thoſe of gold, platina, and antimony, but with none of the earthy ſolutions except muriat of alumine. Thus the ſame teſt duly applied will tell the preſence of any metallic ſalt (with the exceptions above mentioned) and by the colour of the precipitate two or three of the individual metals may be diſcovered, particularly iron and copper; and where iron alone is preſent, the quantity may be found by drying, weighing, and igniting the precipitate, deducting from the reſidue the proportion of iron eſſential to the pruſſiat added. On account however of the great difficulty of preparing an alkaline pruſſiat with an uniform proportion of iron, this teſt is ſeldom employed to aſcertain the *quantity* of iron in any ſolution, but only its preſence.

Two or three good methods have been given for preparing pruſſiat of potaſh. They are all eſſentially the ſame, and are founded on the following principles: when an alkali is digeſted with heat, upon Pruſſian blue, a great part of the acid, and a ſmall part of the oxyd of iron of the blue, unite in ſolution with the alkali, and a yellow pruſſiat of iron with exceſs of oxyd is left, as has already been mentioned. It would ſeem therefore at firſt that no more was required to prepare the pruſſiat of potaſh, than to evaporate the ſolution to the proper point and to cryſtallize. This indeed, if the alkali were ſaturated, would readily afford the cryſtals required; but in this ſtate if any acid is poured on them, a copious ſeparation of blue pruſſiat will take place, and therefore it would lead to great errors in analyſis, as an indication of iron will be given in the liquor examined by this teſt, when it merely contained an exceſs of acid. The reaſon of the effect of acids on this unpurified pruſſiat of potaſh in precipitating blue pruſſiat, ſeems to be, that during the firſt digeſtion of the alkaline ley and Pruſſian blue, a conſiderable portion of the ſub-pruſſiat of iron, of the ſame nature as that left behind, is taken up (for this is found to yield a ſimilar blue precipitate by the ſimple addition of an acid which diſſolves the exceſs of iron) and hence it becomes neceſſary to purify the pruſſiat of potaſh from the whole of this ſub-pruſſiat before it can be depended on as a teſt.

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[1] Journ. Royal Inſt. or Phil. Mag. vol. 4.

The proportions of the conſtituent parts of pure pruſſiat of potaſh are not abſolutely conſtant, but in general they may be ſtated to be thoſe in which the alkali is perfectly ſaturated with the pruſſic acid, and contains the ſmalleſt poſſible quantity of oxyd of iron conſiſtent with the nature of the ſalt. The latter is ſtill very conſiderable, being from 22 to about 30 *per cent.* of the weight of the entire ſalt. It may be found in the following way: take a known quantity (100 grains for example) calcine it to moderate redneſs in a ſilver crucible, by which the pruſſic acid will burn off, and the potaſh and oxyd of iron be left. Waſh the reſidue thoroughly with hot water to diſſolve the alkali, filter, and collect the oxyd of iron left. But as this is in the loweſt ſtate of oxydation in the pruſſiat, calcine it for a ſhort time in a covered crucible with wax, till it becomes magnetic, and then weigh it. When this exceeds about 30 *per cent.* of the pruſſiat employed, the latter generally depoſits Pruſſian blue by the affuſion of acids, and conſequently is impure.

Another ſubſtance that is always found in impure pruſſiat is ſulphat of potaſh, for it is ſcarcely poſſible to obtain any potaſh free from it without unuſual care, and beſides, the Pruſſian blue itſelf contains a little ſulphuric acid obtained from the alum with which it is prepared. This acid may lead to error where the abſence of a metal in any ſolution is to be inferred from the want of a precipitate on adding the pruſſiat, for if the latter contains any ſulphuric acid it will decompoſe and precipitate the ſalts of barytes, and ſtrontian, and (if in quantity) thoſe of lime. The ſulphuric acid muſt therefore be previouſly ſeparated by a ſolution of barytes. It may be here remarked that the delicacy of this teſt is ſo great as to detect ſulphuric acid in the moſt minute quantity; and as moſt of the common pruſſic ſolutions contain this acid, a precipitate is generally formed when a barytic ſolution is added, which was erroneouſly ſuppoſed to ariſe from the union of pruſſic acid with this earth, and this was brought in confirmation of the hypotheſis of the *metallic* nature of barytes. This miſtake was firſt detected by Mr. Meyer of Stettin,[m] which is of importance, as it allows us to uſe barytes to ſeparate the ſulphuric acid from the pruſſiat, without danger of decompoſing the pruſſiat itſelf, unleſs too much be employed.

Pruſſiat of potaſh may be prepared in the following way:

Procure a ſolution of very pure carbonat of potaſh, make it cauſtic or nearly ſo, by lime (in the way mentioned under the article *Potaſh*) put it into a glaſs flaſk, heat it nearly to boiling, and project in it ſome pruſſian blue finely powdered. The blue colour will be taken away almoſt immediately, and turned to brown, after which continue projecting more of the blue, till the portion laſt added no longer loſes its colour. The lixivium is to be boiled for a quarter of an hour, and is then as much ſaturated as it can be in this way, and is to be poured off clear from the ſediment, and the latter edulcorated. Then collect all the clear liquors, heat them and add a little ſulphuric acid moderately diluted, and continue a moderate heat[n] for ſome time, after which a copious precipitate will be formed of pruſſian blue. Separate this by filtration, and aſſay a ſmall portion of the liquor by ſulphuric acid, and if any blue precipitate appears, add more of the acid to the whole liquor, which muſt again be heated for a time. When by aſſaying a portion no more blue precipitate is yielded, evaporate the liquor conſiderably in a gentle heat, and ſet it by to cryſtallize. In a day or two there will be found two ſorts of cryſtals; one of them hard, pointed, and colourleſs, which is ſulphat of potaſh: the other ſofter, yellowiſh, and generally cubical, which is pruſſiat of potaſh. Pick out theſe cryſtals (more of which may be obtained by further evaporation of the mother water) and rediſſove them in cold water, and add to the ſolution gradually ſome pure barytes diſſolved in warm water, or acetited barytes, as long as any precipitate appears, and no longer. The ſolution alſo ſhould be ſomewhat dilute, otherwiſe the precipitation will not ſtop at the point when only the ſulphat of barytes ceaſes to be formed, but pruſſiat of barytes will then be produced, and being not very ſoluble, it will precipitate. Then again evaporate the filtered ſolution, and the pruſſiat of potaſh will now cryſtallize perfectly pure, and of a pale yellow colour. The purity of theſe cryſtals is known by their not aſſuming a blue colour when ſprinkled with muriatic acid. If this teſt ſhould fail they muſt be again diſſolved, treated with acid, and the ſolution evaporated as before.[o]

Mr. Henry gives a proceſs ſomewhat different, by which through the intermede of copper, the pruſſiat is ſtill more effectually freed from ſuperfluous oxyd of iron. It is, in a few words, the following: when the ſolution of pruſſiat of potaſh has been thoroughly purified by ſulphuric acid, inſtead of evaporating it to cryſtallize, pour into it a ſolution of ſulphat of copper in warm water as long as a reddiſh brown precipitate appears. Waſh this pruſſiat of copper thoroughly, and add it by degrees to a ſolution of pure potaſh. The pruſſic acid then quits the copper and unites with the potaſh, ſtill all along carrying with it a conſiderable portion of iron with which it finally cryſtallizes. Then teſt the ſolution with barytes, and evaporate and cryſtallize in the way already mentioned. The ſalt thus obtained is free from ſulphuric acid and contains no more oxyd of iron than is abſolutely neceſſary to its compoſition, and therefore none of the oxyd is unſaturated but is held in ſuch firm union with both the pruſſic acid and potaſh as not to be detached by any ſimple affinity unleſs with the aſſiſtance of heat.

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[m] Phil. Journ. 4to. vol. iv. p. 30.

[n] Henry's Epitome, 4to edit.

[o] Klaproth in Kirwan's Mineralogy.

Pruſſiat of potaſh is a ſalt of a pale amber yellow colour, and eaſily ſoluble in four or five times its weight of water. The alkali is perfectly ſaturated, ſo that it does not alter vegetable colours. When the ſalt, either ſolid or in ſolution, is long heated or expoſed to the light for ſome time it depoſits blue pruſſiat of iron, and hence to keep it for chemical purpoſes it ſhould be put into an opake bottle, or in a dark place. It is not very eaſy to explain preciſely the cauſe of this change. Probably it is in the firſt inſtance produced by the diſſipation of a portion of the pruſſic acid in the part immediately expoſed to light, which leaves the remainder of this part in thoſe proportions in which the blue pruſſiat is conſtituted; but as the latter contains ſcarcely any alkali, it is neceſſary that the correſponding portion of potaſh ſhould alſo be detached from the part that has loſt ſome of its acid before the blue pruſſiat can appear. What are the affinities that produce this effect?

The pruſſic acid will alſo unite to ſoda and ammonia by a ſimilar proceſs to that already deſcribed.

It is not abſolutely neceſſary in forming any of the pruſſiated alkalies that the alkali ſhould be in a cauſtic ſtate, but it very much aſſiſts and ſhortens the operation.

Pruſſiat of Lime. When pruſſian blue is boiled with lime-water the ſame diſcoloration takes place as with potaſh, and the lime in ſaturating itſelf with the pruſſic acid becomes of a clear yellow colour. This liquor alſo depoſits blue pruſſiat by expoſure to light. It is an uſeful teſt for iron and copper, but on account of the lime it contains it is decompoſed partially by ſulphuric acid in many forms.

Pruſſiat of Barytes. This ſalt is formed in the following way, and has been examined particularly by Mr. W. Henry.[a] Make a ſolution of pure barytes in boiling water, and add by degrees pure pruſſian blue in fine powder (previouſly waſhed with hot water) till it ceaſes to be diſcoloured. Filter the ſolution, and after ſtanding a few hours ſmall yellowiſh cryſtals will appear, which are the pruſſiated barytes. From the remaining ſolution a further quantity of cryſtals may be obtained by evaporation. Their form appears to be a rhomboidal parallelopiped. This ſalt is very ſparingly ſoluble in water, 4 oz. of which at 65° diſſolve only one grain, and of boiling water 5 or 6 grains. It is totally ſoluble in dilute muriatic and nitric acid, and without decompoſition. When heated to redneſs the pruſſic acid burns off, and the reſidue contains carbonat of barytes. Sulphuric acid, or any ſulphat added to the ſolution of this ſalt decompoſes it compleatly, and ſulphat of barytes is precipitated. It is alſo decompoſed by carbonat of potaſh, carbonated barytes falls down, and the ſolution contains pruſſiat of potaſh in great purity. This would be a ſhort and unexceptionable way of preparing this latter ſalt, but very expenſive. Pruſſiat of barytes may alſo be formed by the double decompoſition of pruſſiat of potaſh and muriated barytes. When theſe ſalts are added together, if no ſulphuric acid in any form be preſent, and the ſolution rather dilute, no immediate change in the tranſparency takes place; but after ſtanding together for a few hours the bottom of the veſſel becomes covered with minute cryſtals, which are pruſſiated barytes. It is this circumſtance of ſome time being required to cauſe this precipitation that gives the opportunity of purifying pruſſiat of potaſh by barytic ſolution from ſulphuric acid, without decompoſing the pruſſiat of potaſh, as the ſulphat of barytes falls down *immediately*, but the pruſſiat requires ſome time, ſo that the addition of the barytes ſhould ceaſe when the ſolution no longer gives an immediate precipitate. Barytic water added to pruſſiat of lime decompoſes it and cryſtals of pruſſiated barytes gradually form.

Pruſſiat of Strontian.[a]

This ſalt is prepared like the former by digeſting pruſſian blue with the pure earth. But this pruſſiat does not readily cryſtallize, and appears to be extremely ſoluble in water. It is not exactly determined, whether muriated or nitrated ſtrontian decompoſes pruſſiat of potaſh. Pure barytes added to pruſſiated ſtrontian, cauſes a precipitate of pruſſiated barytes, but in very ſmall quantity, ſo that it appears to decompoſe it only partially, and hence the affinity of barytes for this acid is not much ſtronger than that of ſtrontian.

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[a] Phil. Journ. 4to. vol. 3 and 4.

[b] Ditto.

The affinities of the pruſſic acid are extremely difficult to be made out on account of the peculiar tendency which it has to form triple and even quadruple combinations. Among the metals, mercury appears to ſtand firſt and iron next, and among the earthy and alkaline baſes the order is probably barytes, ſtrontian, potaſh, and lime.

PUDDING STONE.

This term, invented by the Engliſh lapidaries, is applied by them to deſignate one particular mineral aggregate, conſiſting of oblong and rounded pebbles of flint, about the ſize of almonds, imbedded in a hard ſiliceous cement: the pebbles are uſually black, and the cement is a light yellowiſh brown. It is capable of receiving a very high poliſh, and uſed to be much employed in inlaying and other ornamental works. It is chiefly procured from the county of Eſſex. Many of the French mineralogiſts have naturalized this term (Poudingue) and have applied it to all rounded ſtones imbedded in a cement, ſo as to make it nearly ſynonimous with the German *Agglomerat*, and the Engliſh *Rubble-ſtone*.

PUMICE. Bimſtein, *Wern.* Pierre Ponce, *Broch.*

The colour of this mineral is greyiſh white, bluiſh or yellowiſh grey, greyiſh black and reddiſh brown. It occurs in maſs and diſſeminated, being always more or leſs cellular or carious. It is gliſtening, ſometimes even ſhining, with a ſilky luſtre. Its fracture is fibrous. Its fragments are indeterminate moderately ſharp edged. It is opake, ſometimes a little tranſlucent on the edges. It is ſoft, that is, is readily ſcratched or pulverized, but its particles when in powder have a conſiderable hardneſs. It is brittle and very meagre to the touch. Sp. gr. 0.91.

It is fuſible without addition before the blow pipe into a white enamel. It is compoſed according to Klaproth of

77.5	Silex
17.5	Alumine
1.75	Oxyd of Iron
96.75	
3.25	loſs
100.	

It is generally looked upon as a volcanic product. It is wrought in conſiderable quarries in the Lipari iſlands, which are almoſt entirely compoſed of this mineral. It alſo occurs in Sicily and Iceland.

Pumice ſtone is extenſively uſed for grinding down metals, glaſs, ivory, &c. previous to poliſhing; it is alſo employed for ſmoothing leather, and other ſimilar purpoſes.

PUTREFACTION.

Putrefaction is that ſpontaneous proceſs of decompoſition which takes place in all the ſoft parts of animals, and ſome vegetables under proper circumſtances of temperature and moiſture, by which they are finally diſorganized, and are chiefly reſolved, when with acceſs of air, into a variety of gaſeous and volatile compounds, which mingle with the atmoſphere.

The ſubject of putrefaction is ſtill very obſcure, that is to ſay, though we know the circumſtances required for it, and many of the products, we are very far from poſſeſſing exact ideas concerning the mode in which the conſtituent parts of the animal body break up their former combinations, and form new ones altogether different.

Putrefaction is naturally a very ſlow proceſs, and the inſuperable diſguſt and loathing attending it ſeem to forbid a very minute enquiry into this important phenomenon of nature.

We ſhall only mention a few of the facts known concerning it. The circumſtances requiſite to the putrefaction of animal matter, are a temperature from about 40° to the higheſt natural heat, and a conſtant moiſture in the ſubſtance putrefying. The operation of a freezing temperature in ſtopping putrefaction is well known, by the conſtant cuſtom in cold countries of bringing victuals frozen to market, in which ſtate they will keep for any length of time without any other preparation; by bodies of men or other animals remaining unaltered under ice for many weeks, and the like. On the other hand, a ſcorching heat alſo prevents putrefaction, which it does however, apparently, ſimply by expelling the moiſture which is eſſential to the proceſs, for by any inferior degree of heat putrefaction is much promoted. For the ſame reaſon alſo ſubſtances putrefy much more ſlowly when expoſed to a drying wind, than in a ſheltered place.

The obvious phenomena of putrefaction are the following, in any animal matter kept at a pretty uniform temperature, in a place not much expoſed to currents of air, the ſubſtance firſt becomes ſoft and flabby, or if it is already ſoft, as in the caſe of the coagulum of blood, it reſolves itſelf into a dark fluid, the colour then changes to green or brown, and an unpleaſant ſmell begins to iſſue from it. As the proceſs advances the ſoft parts then melt down into a putrid pulpy maſs, and the fluids become turbid, and the effluvia become exceſſively loathſome and ſickening, and after a time, the parts ſwell and become puffy, and diſengage the putrid gas in a ſlow but ſenſible efferveſcence. A foul and brown ſerum then ſweats out from the pulpy maſs, and about this time the effluvium is very ſenſibly ammoniacal as is apparent from its effects on the eyes and throat, and by forming a white vapour with muriatic acid gas. Things continue nearly in this ſtate for a conſiderable time, during which a large part of the putrid ſubſtance is evaporated, and carried off in the putrid gas and diſperſed in the atmoſphere, after which the extreme fœtor ſubſides, and finally the proceſs of putrefaction ceaſes, and leaves a kind of fat fœtid earthy matter.

Such is the regular proceſs of putrefaction, as far as relates to the external circumſtances, and obvious phenomena, but it may be obſerved, that ſome parts putrefy much more readily than others, and ſome ſcarcely at all. Perhaps the moſt putreſcent ſubſtance that we know is the blood, which property it owes partly to its fluidity and partly to the large quantity of fibrin and uncondenſed albumen, which it contains, and eſpecially to the former. Animal parts alſo ſeem to be (ceteris paribus) more putreſcent in proportion to the number of conſtituent parts which they contain. The ſubſtances abſolutely or nearly imputreſcible, are bone and *condenſed* albumen, the latter ſuch as it exiſts in cuticle, nail, hair, &c. which long remain unaltered in the midſt of putrefying ſubſtances. Animal *oil* alſo putrefies with great difficulty, and hence the people that live in the moſt northern parts of America, the Eſkimaux and others, preſerve fiſh and meat to a certain degree from putrefaction by immerſion in fiſh oil.

The gaſſes certainly known to be produced by putrefaction are carbonic acid, carburetted hydrogen, ſulphuretted and phoſpuretted hydrogen, and ammonia, but either theſe or ſome of theſe muſt be conſiderably changed by the ſolution of the animal matter, or ſome compound not yet examined muſt be produced in that ſtate of putrefaction where the gas evolved occaſions ſuch dreadful effects upon thoſe that unfortunately fall in the way of it, even when diluted conſiderably with common air. This is ſaid to be the caſe when the abdomen of a large animal is firſt burſt after ſome days, or perhaps weeks of putrefaction; the gas from which cauſes inſtant fainting, and ſometimes death, and even when the perſon expoſed to it recovers the firſt ſhock, it leaves exceſſive debility and other alarming ſymptoms for a conſiderable time. The moſt deleterious gas that we know is, perhaps, carburetted hydrogen, but the effects of this as obtained by chemical means, are far ſhort of thoſe above mentioned, when equally diluted.

The generation of ammonia has been ſatiſfactorily accounted for ſince the diſcovery of the conſtituent parts of the volatile alkali, by the new combination formed between the azot of the animal matter, and the hydrogen, of which latter there are many ſources, and particularly that of the decompoſition of water. As ammonia is always produced during putrefaction, it ſeems rational to ſuppoſe that one important purpoſe of the moiſture neceſſary to the proceſs is to afford, by its decompoſition, the hydrogen of the volatile alkali.

The circumſtances which tend to the generation of the nitrous acid, (which is an undoubted product of putrefaction) have been mentioned under the article *Nitrat of Potaſh*, but many more experiments muſt be made, and facts obſerved, before we can explain, why in certain caſes the azot tends to unite with oxygen to form this acid, and in others with hydrogen to form ammonia.

That peculiar change which takes place in animal fleſh, whereby it is converted into a ſpermaceti-like ſubſtance inſtead of undergoing the uſual mode of putrid decompoſition, has been mentioned under the article *Adipocre.*

PUTTY.

True putty is made by calcining an alloy of equal parts of tin and lead: a white powder is thus produced that is the baſe of moſt of the opake enamels, and is alſo uſed in the poliſhing of metals, ſtones, and glaſs.

The glaziers' putty, uſed by them for faſtening panes of glaſs into ſaſhes, was perhaps originally compoſed of true putty and oil; but at preſent it is nothing but waſhed chalk or whiting mixed up with linſeed oil; a ſort of ductile paſte is thus produced which becomes hard after a few days expoſure to the air.

PUZZOLANA.

Puzzolana appears to be nothing elſe than volcanic aſhes more or leſs compacted together. It occurs either white, red, or black, has a dull earthy fracture, and is eaſily frangible. It abounds in the vicinity of Veſuvius. The red variety is the proper puzzolana, the black and the white are called in Italy *lapillo* or *rapillo*. The aſhes which overwhelmed Pompeia now form a vaſt bed of white puzzolana. It is employed in calcareous CEMENTS to which it gives the property of hardening under water.

PYRITES.

A name firſt given by the ancient naturaliſts to the native ſulphuret of iron, becauſe when ſtruck againſt a piece of ſteel or other hard body, it gives out ſparks of fire, and becauſe when heated red hot the ſulphur that it contains burns with a lambent blue flame. Modern mineralogiſts diſtinguiſh three ſpecies of pyrites, namely, the ferruginous, the cupreous, and the arſenical, of which the firſt is ſulphuret of iron, the ſecond ſulphuret of copper, and the third is a compound of iron pyrites and arſenic. All theſe ſubſtances have a general ſimilarity in their external appearance: their colour varies from yellowiſh white to gold yellow, and they have all a high metallic luſtre. For further particulars ſee the ores of ARSENIC, COPPER, and IRON.

PYROLIGNEOUS ACID
PYROMUCOUS ACID
PYROTARTAREOUS ACID
See ACETOUS ACID, *Empyreumatic*.

PYROMETER. (*Wedgewood's.*)

The range of the common mercurial thermometer extends no higher than the boiling point of this metal (that is about 600°) and even this is a very inaccurate meaſure of heat in its higher part on account of the very unequal expanſion of mercury as it approaches boiling. But this point falls ſhort of that of the loweſt viſible red-heat, and from this to the higheſt temperature that furnaces will produce, a vaſt range of heat is included, for which no tolerably accurate method of meaſurement exiſted till the year 1782,[a] when the late Mr. Wedgewood invented his pyrometer. Previous to this time chemiſts were in the habit of uſing very vague terms to expreſs the heat employed in their operations, ſuch as *red heat*, *full-red heat*, *white heat*, &c. and the means uſed for meaſuring it were too inaccurate for the experimental chemiſt, though ſufficient for the manufacturer when aided by daily experience. Theſe were generally the degree of fuſibility ſhewn by refractory earthy mixtures, the length of time which the crucible could endure the heat employed, the reduction of metallic oxyds and the like. Another method which is actually employed in the potteries, and anſwers ſufficiently well, is the ſhade of colour produced by the heat on a ring of clay worked up with a little oxyd of iron. This is a light brown, or fleſh colour in the lower red heats, but gradually darkens to a deep chocolate, or almoſt to blackneſs as the fire reaches its utmoſt intenſity. This mode however can hardly be applicable as a general ſtandard of compariſon, as the ſhades of colour are not very definable, and not readily deſcribed, beſides other objections which might be raiſed.

Mr. Wedgewood, therefore, on examining this ſubject, which his buſineſs as a potter rendered peculiarly intereſting, found a new and much more accurate meaſure of temperature in the gradual, and on the whole pretty uniform contraction, which clay undergoes in all heats from the fainteſt red to the moſt intenſe which can be produced. From examining with minute attention the habitudes of clay with water and fire, and from the event of many experiments Mr. W. gives the following as the general reſult of his obſervations.

When a ſolid lump of pure natural clay, (ſuch as the fineſt Devonſhire kind) is well kneaded with water, and expoſed very gradually to an increaſing heat, the firſt change that takes place is the ſhrinking produced by the ſimple evaporation of water. The purer the clay is the more water it takes to ſoften it, and therefore the more it diminiſhes in bulk by the loſs of moiſture. The clay dries at a heat below redneſs, and preſerves its bulk unvaried up to the approach of ignition. At this period it *enlarges* a little, owing probably to the eſcape of air with which it has been combined.

When this air has made its eſcape, the clay begins to ſhrink and returns to preciſely the ſame dimenſions which it had before, when thoroughly dry. When thus prepared and brought to this point, it is fit to be uſed for the pyrometer, and forms the beginning or loweſt point of the ſcale, which as above-mentioned is the loweſt heat of *ignition*, or that in which a body is juſt perceptibly red-hot in the day time. From this point it ſhrinks gradually and pretty uniformly in proportion as the heat is increaſed, till it reaches its utmoſt degree of contraction, (which varies according to the nature of the clay,) thus forming a range which may be uſed for thermometric purpoſes. In the pureſt natural clays it reaches nearly to the higheſt artificial heat procurable in furnaces, but in other clays, though to the eye equally pure, the contraction ſtops very ſhort of this, and then a *ſecond expanſion* takes place.

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[a] Phil. Tranſ. for 1782, 4, and 6.

At this time it is intenſely hard, and has a texture approaching to the *vitreous*, ſo that the ſecond enlargement appears to depend in part perhaps, on a further diſengagement of gas, but chiefly probably on an alteration in its texture. During the firſt part of the pyrometric ſcale, (that is from low redneſs upwards) the clay continues bibulous and ſticks to the tongue. This ceaſes however ſome time before the ſecond expanſion comes on, whence Mr. Wedgewood conjectures, that the *porcellanous* ſtate (which is intermediate between the earthy and the vitreous) comes on when the clay ceaſes to be bibulous, and remains till the vitreous expanſion begins. It may be obſerved, as before mentioned under the article *Alumine*, that the ſhrinking which takes place after ignition cannot be attributed to the evaporation of water or any other ſubſtance, for the loſs of weight is much too ſmall to allow of this explanation. The entire contraction, from ignition to the higheſt procurable furnace-heat, is full one-fourth of the bulk of the clay in every dimenſion, when it remains unvitrified at ſo high a temperature; but the loſs of weight from ignition to the heat that melts copper, which is about a ſixth of the entire contraction, is only 2 per cent. of the weight of the clay, and above this latter point no loſs is perceptible by the balance.

It has been mentioned above that ſamples of clay though apparently equally pure and white, and even taken from the ſame bed, though ſufficiently ſimilar for moſt purpoſes of manufacture, do not undergo the ſame degree of ſhrinking in the fire; for ſome continue to contract at every procurable intenſity, whereas others, above a certain point, again expand and aſſume a vitreous texture. Neither do the *firſt* expanſions, which take place juſt at ignition, ſufficiently correſpond. This circumſtance cauſed a good deal of embarraſſment to the inventor, as after the firſt ſample of pyrometer clay was exhauſted, (which happened to be of the kind the moſt refractory in the fire) he could not be certain of obtaining another maſs which would correſpond with the former in contraction. This led him to examine the contraction of pure alumine precipitated from alum by an alkali (that is to ſay, as pure as it is uſually obtained without extreme precaution and great expence, and therefore ſtill retaining both ſulphuric acid and potaſh) and he found that it continued to contract, and even remained bibulous ſo as hardly to become porcellanous, by the higheſt heat of a furnace. This prepared alumine when mixed in certain proportions with the natural clays alſo rendered them ſufficiently unalterable in texture in the fire, and brought their contractions to correſpond with thoſe of the pyrometer-pieces already made. The alumine is prepared by precipitating a ſolution of alum with good pearlaſh, and waſhing it repeatedly with large quantities of boiling water. The precipitated earth when it is ſomewhat condenſed by ſettling, is to be uſed in that gelatinous ſtate undried, as it then mixes much more eaſily with the natural clay. Mr. W. found that a maſs of ten hundred weight of the ſecond clay which he employed required all the earth of five hundred weight of alum to bring it to the ſame ſtate with the pyrometer-pieces already made. This prepared alumine is much more tenacious of water than common clay, ſo that the mixture requires a more careful drying and at a higher temperature, before the ſize of the pieces is adjuſted, and this ſhould be done immediately after giving them a boiling-water heat, as they again abſorb ſome moiſture from the air (owing doubtleſs to the potaſh contained in the alumine) which would make the difference of two or three degrees of the ſcale, if the adjuſtment was delayed till that time.

The pyrometer is actually made in the following manner. It conſiſts of two parts, the clay-pieces and the braſs gage. Each clay-piece is a ſection of a cylinder of clay about the thickneſs of the little finger, and the length about equal to the diameter. One ſide is a little flattened, that it may ſlide more accurately along the gage. This latter conſiſts of a long canal formed by two perfectly ſtraight bars of braſs fixed on a plate of the ſame metal in a converging direction, and graduated into 240 equal parts, beginning at the wideſt extremity. The width of the canal at one end is to that at the other in the proportion of 5 to 3. The gage to be more portable, is cut in halves, which are placed ſide by ſide on the ſame plate.

The clay pieces are previouſly baked juſt to ignition, or to a red-heat barely viſible in the day-time, and when applied to the gage they juſt reach the o. of the ſcale. Every increaſe of heat contracts the piece, which therefore can be ſlid further into the gage. The clay pieces will bear the moſt ſudden heating and cooling without in the leaſt cracking or ſplitting, and indeed their ſize is ſuch that in two or three minutes that they have undergone the utmoſt effect of any particular degree of fire, ſo that no long continuance of the ſame heat is neceſſary. To employ this pyrometer one of the pieces muſt be put in or contiguous to the part where the heat is to be aſcertained, incloſed if neceſſary in a very ſmall crucible. If thrown on burning coals in a high heat it becomes ſomewhat rough on the outſide and firmly covered with a kind of black enamel, which poſſibly may render it leſs accurate. It ſhould alſo be kept from the immediate action of any ſaline or other fluxes which would corrode its ſurface and impair its accuracy, but in other reſpects it requires but little precaution. It is a peculiar property, and generally an advantage, of this pyrometer, that each clay-piece tells only the extremeſt heat to which it has ever been expoſed, and never returns to any inferior point of the ſcale like all other thermometers, ſo that it may be gaged at any diſtance of time from the experiment. Even if the piece is broken or injured, if the compleat ring of the cylinder remains, of whatever breadth, it forms as accurate a meaſure as when entire.

The degrees of this pyrometer only begin at a conſiderably greater heat than the termination of the mercurial thermometer, and hence in order to render them at all comparable, it became neceſſary to connect the two by ſome intermediate ſcale. This Mr. Wedgewood effected by comparing the expanſion of a ſilver gage in the intermediate degrees; and by experiments, which it is not neceſſary here to detail, he was able to connect the two ſcales in a tolerably ſatisfactory way; though the heats are ſo remote that very little advantage can ever be derived from this method. Mr. W. found that the mercurial range of temperature was ſo ſmall compared with the pyrometrical, that a ſingle degree of the clay pyrometer was equivalent to 130 degrees of Fahrenheit, and the o. of the pyrometer, which is a low red heat, he found to fall at about 1077° Fahr. ſuppoſing the mercurial ſcale could be continued ſo high, and with an uniform expanſion of the mercury. Mr. W. has extended the ſcale of his pyrometer to 240 degrees; this is entirely arbitrary, but it probably is more than amply ſufficient to include all poſſible production of heat, ſince the greateſt intenſity of furnaces has not been found to exceed about 180 of this ſcale. Theſe 240 degrees are eſtimated from the above data to be equivalent to 31200 degrees of the mercurial thermometer, and as the o. of the former is equal to 1077° Fahr. the extreme of the pyrometer ſcale would correſpond with 32277° Fahr. could this be continued as high. Hence too the whole diſtance between freezing and boiling water, or from 32° to 212° Fahr. is equivalent to no more than about half a degree of the pyrometer.

We ſhall now give the pyrometrical correſpondences with ſome of the moſt eaſily obſerved ſtages of the higher heats as obſerved by the inventor and others.

Red heat fully viſible in day-light	0
Enamelling heat for pottery	6
Braſs melts at	21
Swediſh copper melts at	27
Fine ſilver melts at	28
Fine gold melts at	32
Vitrefying (or higheſt) heat of a plate-glaſs furnace	124
Working heat of ditto	57
Welding heat of iron	120 to 132
Greateſt heat of a common ſmith's forge	125
Caſt iron melts at	130
Baſalt melts at	100
Antient Etruſcan ware begins to contract (and therefore was baked) at	from 30 to 20
Ditto compleatly melts at	36
Delft ware baked at	40
Queen's pottery ware baked at	86
Stone ware baked at	102
Worceſter china vitrefied at	94
Derby ditto ditto at	112
Chineſe porcelain only ſoftens at	120
Ditto ſinks down into ſemi-fuſion at	156
True ſtone Nankeen does not in the leaſt alter at	156
Pyrometer pieces aſſume a porcellanous texture at	110
Greateſt heat of the beſt conſtructed air furnace probably does not exceed	about 180

It remains to mention ſome uncertainties that ſtill attend the uſe of this inſtrument, and the difficulty in adjuſting a ſufficiently accurate ſtandard of compariſon.

The inventor obſerves that a correſponding pyrometer may always be conſtructed by making for a gage a converging canal with the widths at the two ends in the proportion of 5 to 3, with the ſides perfectly ſtraight, and divided into 240 equal parts—and by procuring natural or artificial clay, pieces of which will juſt enter the gage at a low red-heat, will go to 27° by the heat at which copper melts, to about 90° by the welding heat of iron, and about 160 by the greateſt heat of an air furnace, the clay pieces all the while remaining perfectly refractory.

But the great difficulty which the inventor himſelf ſeems to have had in preparing a ſecond parcel of clay ſimilar in theſe reſpects to that already employed is of itſelf ſufficiently diſcouraging, nor are the points which he gives for the conſtruction of the ſcale at all comparable in accuracy with thoſe by which the common thermometers are graduated. The heat of boiling water and of melting ice are fixed points in which (with a few ſimple precautions) every one would agree, but it is not ſo with a red heat barely viſible in day-light, and ſtill leſs with the utmoſt power of a wind-furnace of given dimenſions. Even the fuſing point of copper is liable to ſome variations according to the purity of the metal, and that of caſt-iron is ſtill more variable on this account, ſo that though we may conſider Mr. Wedgewood's ſcale as affording very uſeful approximations to the expreſſions of comparative heats, it does not approach the accuracy of the mercurial thermometer. Neither have we any means of aſcertaining in the higher heats whether the contraction of clay is at all equable, that is, whether equal numbers on the pyrometrical ſcale expreſs equal increments of heat, as they do pretty accurately with the mercurial thermometer.

The analyſis of Mr. Wedgewood's pyrometer pieces as conducted by Scherer,[a] ſhews them to be made of a very pure natural clay compoſed of about 54 per cent. of alumine, and 44 of ſilex, with hardly a trace of any other ingredient. As the Devonſhire clays contain a much leſs proportion of alumine than is here given, the above pieces were doubtleſs made, as indicated by Mr. Wedgewood, by adding to the natural clay a conſiderable portion of precipitated alumine.

But on the other hand, Gazeran[b] in his experiments on this ſubject found the beſt imitation of the Wedgewood pieces to be produced by a clay in which the alumine was to the ſilex as 34 to 43, and pieces made of this material correſponded very cloſely with the original Wedgewood pieces at the heat of 160°, and ſhewed no ſign of vitrification at this high temperature.

This ſubject therefore, which is highly intereſting to the chemiſt and manufacturer, requires further experiments.

PYROPE. See Garnet.

PYROPHORUS, Homberg's.

This preparation was firſt diſcovered by the chemiſt whoſe name it bears, as the reſidue of the diſtillation of fecal matter with alum and vitriol. Improvements with reſpect to the cleanlineſs of the proceſs were ſoon introduced, and the following is now the common mode of preparing this ſubſtance.[a] Take three parts of Roman alum in powder, and one part of coarſe brown ſugar, mix them together and heat the maſs over a common fire in an iron ladle or a ſhovel. By the firſt impreſſion of the heat both the alum and ſugar melt and mix intimately with each other; after a little time when moſt of the water is evaporated, the reſidue begins to foam and ſwell conſiderably, and to give out a pungent empyreumatic acid: it muſt now be ſtirred conſtantly with an iron ſpatula, taking care to detach it from the ladle in proportion as it dries, and to heat every part as uniformly as poſſible: when the laſt remains of clammineſs are deſtroyed, and the ſpungy black matter that is left is quite friable, it muſt be transferred while hot into a mortar, and haſtily reduced to a ſomewhat coarſe powder. As ſoon as it is pulverized, a green glaſs vial of the capacity of about ſix ounces, (previouſly luted on the inſide by rinſing it out with a weak ſolution of borax thickened with pipe clay to the conſiſtence of cream) is to be nearly filled with it and then ſet up to the neck in a crucible filled with ſand, its mouth being looſely ſtopped with a piece of charcoal. The crucible is now to be placed in a furnace, or even in an open fire, and raiſed gradually to a moderate red-heat. At firſt a denſe white vapour will iſſue from the vial for nearly a quarter of an hour, and will then be ſucceeded by an inflammable gas, burning with a light blue flame: as ſoon as this makes its appearance, the heat is to be kept up at an uniform temperature for about 20 minutes longer, after which, the crucible with its contents being removed from the fire, and the mouth of the vial being cloſed with a plug of paper, it is to be quickly cooled till the vial can be ſafely handled; the pyrophorus is then to be haſtily poured into a warm and perfectly dry ground-ſtoppered vial, in which it may be kept without injury for any length of time provided the acceſs of air is carefully avoided.

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[a] An. Chim. tom. xxxi. p. 172.

[b] Ditto, tom. xxxvi.

[a] Beaumé Chim. exper. I. p. 338.

Another excellent method of preparing pyrophorus is the following.[b] Mix together three parts of Roman alum and one of flour, and heat the mixture to dryneſs in an iron pot, as deſcribed in the preceding paragraph: the black calcined maſs thus produced, is to be put into ounce phials of green glaſs, coated without and within with clay. The phials thus charged are to be lightly ſtopped with balls of tempered clay and then ſet up to their necks in ſand in an iron pot; charcoal powder is then to be ſtrewed on to the depth of half an inch, over which is to be placed an earthen cover, luted to the pot. The whole apparatus is now to be placed in a furnace and kept at a red-heat for an hour and a half: at the expiration of this period being taken out of the furnace and cooled quickly, it is to be unpacked, and the phials containing the pyrophorus are to be placed with their mouths inverted in mercury, in which ſituation the pyrophorus may be kept for many years without injury.

Pyrophorus is a light dry black powder, which when poured out in a little heap on any flat ſurface, and expoſed to the air, preſently gives out an odour of ſulphuretted hydrogen, and in about a minute becomes red-hot, and burns with a very light bluiſh flame till the whole of the carbonaceous and other inflammable matter is entirely conſumed, nothing being left but the white earthy baſe of the alum. Sometimes, either from a defect in the preparation, or from the air not having been entirely excluded from the phial in which it is contained, the pyrophorus when poured out undergoes no ſenſible change; when this happens, however, the combuſtion may often be brought about by breathing on the powder, and thus ſupplying it with the moiſture which ſeems to be the primary agent in this phenomenon. Pyrophorus when made according to the laſt mentioned manner is ſo very inflammable as to take fire as it is falling from the mouth of the phial. If poured into a jar of pure oxygen gas it forms a brilliant fiery ſhower; the oxygen is for the moſt part conſumed, and there remain in the jar ſulphureous acid and carbonic acid gaſſes: the pyrophorus alſo being conſumed, with the exception of its aluminous baſe.

The chemical changes that take place during the formation and decompoſition of pyrophorus, appear to be the following. Firſt, by being heated below redneſs in the open air the ingredients enter into fuſion, and thus mix accurately with each other, then the water of cryſtallization is driven off from the alum, and of the ſugar or flour little elſe than the charcoal eſcapes volatilization. Secondly, the red-heat to which it is expoſed in the phial, cauſes the ſulphuric acid of the alum and the charcoal of the ſugar to react on each other, by which part of the charcoal is driven off in the form of carbonic acid, and part of the ſulphuric acid eſcapes as ſulphureous acid: the blue flame that characteriſes the latter part of this proceſs is in all likelihood cauſed by the volatilization and combuſtion of a portion of ſulphur, more than is requiſite to ſaturate the potaſh of the alum. Thus the pyrophorus when prepared, conſiſts of alumine, charcoal, and ſulphuret of potaſh in intimate mixture. Thirdly, when this powder is expoſed to the air a rapid decompoſition both of the air itſelf and of the moiſture that it contains takes place, the oxygen of each being abſorbed by the ſulphuret, while a ſufficient quantity of heat is diſengaged to bring the charcoal and remainder of the ſulphur to a ſtate of actual inflammation.

PYROXENE. See Augite.

Q

QUARTATION.

A method of ſeparating gold from ſilver. See Assay *of Gold*; and Gold, p. 528.

QUARTZ. *Quartz*, Broch. *Quarz*, Wern.

We ſhall ſubdivide this mineral into the five following ſubſpecies.

1 *Subſp.* Cryſtallized quartz. Rock cryſtal.

Rock cryſtal often occurs perfectly tranſparent and colourleſs, it is alſo found reddiſh, yellowiſh and greeniſh white, pearl grey, ſmoke grey, greyiſh black, honey yellow, clove brown, yellowiſh and blackiſh brown, wine yellow, ochre yellow, hyacinth red, blood and brick red, reddiſh purple, apple green, leek green, and olive green. Its primitive form is a rhomboid approaching nearly to a cube. But though this figure may be obtained by mechanical diviſion of the priſmatic cryſtals, it has never yet been found native. The known varieties which it exhibits are the following.

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[b] Higgin's Minutes, p. 271.

1. The pyramidal dodecahedron, compoſed of two ſix ſided pyramids joined baſe to baſe, the angle formed by the plane of one pyramid and the correſponding plane of the other is =103° 20′ and the angle formed by any two of the adjacent planes of the ſame pyramid is =133° 40′.

2. The preceding, with a ſtrait hexahedral priſm interpoſed between the two pyramids, the angle formed by any plane of the pyramids and the adjoining plane of the priſm is =141° 40′.

3. The ſame as var. 2, with the alternate ſolid angles at the baſe of each pyramid replaced by ſmall rhombic planes.

4. The ſame as var. 2, with all the ſolid angles at the baſe of each pyramid replaced by trapezoidal planes.

5. The ſame as var. 2, with the horizontal edges of the priſm replaced by trapezoidal, almoſt parallelogramatic planes.

The ſize of the cryſtals varies from ſmall to very large; ſome of the largeſt priſms are more than two feet in length, and weigh above 100 lbs. The planes of the priſms are tranſverſely ſtriated, but thoſe of the terminating pyramids are ſmooth. The cryſtals are commonly brightly ſhining, both externally and internally, with a vitreous luſtre. Its fracture is conchoidal, paſſing occaſionally into obſcurely foliated. The fragments are indeterminately angular, and very ſharp-edged. The colourleſs or ſlightly coloured varieties are uſually tranſparent, but thoſe that are much loaded with iron ochre are often only tranſlucent: when tranſparent it exhibits a double refraction.

Its hardneſs is ſuperior to that of glaſs, and it gives vivid ſparks when ſtruck againſt a ſteel. It is brittle and eaſily frangible. Sp. gr. 2.65 when pure, but when deeply coloured by metallic oxyds it is conſiderably more.

When two cryſtals are rubbed together they afford a phoſphoreſcent light, and exhale a peculiar odour. By expoſure to the blowpipe this mineral undergoes no change, except that certain of its varieties loſe their colour. Even a blowpipe charged with oxygen gas is wholly incapable, according to Lavoiſier, of inducing the leaſt ſign of fuſion. According to Ehrmann however, it melts into an enamel, but in this caſe the quartz was probably heated on charcoal from which it might acquire potaſh enough to ſerve as a flux.

The purple variety, called amethyſt, is compoſed according to Roſe, of

97.5	Silex
0.25	Alumine
0.5	Iron and a trace of manganeſe
98.25	

Several of the varieties of cryſtallized quartz are uſed as ſeal-ſtones and ornaments of various kinds, on account of their hardneſs, the exquiſite poliſh that they are capable of receiving, and the pleaſing tone of their colours. The moſt perfectly tranſparent and colourleſs is called by the lapidaries *rock cryſtal*, and beſides being applied to various purpoſes of ornament, it is cut into ſpectacle glaſſes, which from their hardneſs are not ſo liable to be ſcratched as thoſe which are made of flint glaſs. The reddiſh purple or violet coloured variety is called *Amethyſt*, and is occaſionally ranked among the gems: it muſt not however be confounded with the oriental amethyſt, which is a true gem, being a variety of corundum. The pearl grey or pale blue variety is called falſe, or *water ſapphire.* The yellow and ſmoke coloured varieties are called *falſe topaz.* The green varieties are not unfrequently miſtaken for chryſolite.

The largeſt and moſt eſteemed cryſtals of quartz come from Madagaſcar, alſo from the Alps, from Norway, and Scotland, where they occur lining cavities in granite. Amethyſt is commonly found in geodes of agate, and is chiefly procured from Catalonia in Spain; from Bohemia, Saxony, Sileſia and the Palatinate in Germany; from Hungary; from Auvergne in France, and the Uralian mountains near Catherinenburg in Ruſſia. Quartz cryſtals alſo occur in moſt metallic veins both of ancient and recent formation in every kind of rock.

There is ſcarcely any cryſtallized mineral ſo liable as quartz to contain foreign ſubſtances; ſometimes drops of water and bubbles of air may be obſerved in it, alſo fibres of amethyſt, capillary cryſtals of ſchorl and ruthil, ſcales of chlorite, and dendritical iron ore, &c.

2 *Subſp.* Fibrous quartz.

Its colour is yellowiſh or greyiſh white, and ſometimes pale amethyſt. It occurs in maſs: it has a faintly ſhining vitreous luſtre: its fracture is thick and ſhort fibrous, either parallel, diverging, or radiated: the radiated is compoſed of globular diſtinct concretions, two inches or more in diameter. It is tranſlucent, ſometimes ſemi-tranſparent. In its other characters it agrees with the preceeding ſubſpecies.

It occurs in veins and lining cavities, in both which ſituations it is generally in immediate contact with the rock in which they are formed. The variety with globular diſtinct concretions has hitherto been found, we believe, only in Cornwall, where it conſtitutes the great dyke or croſs courſe which paſſes entirely acroſs that country from north to ſouth, cutting through and altering the direction of the metallic veins of that rich diſtrict.

3 *Subſp.* Granular quartz.

Its colour is ſnow white, yellowiſh or greyiſh white. It occurs in maſs and as a component part of certain granites. Its luſtre varies from ſhining to glimmering. It occurs in granular diſtinct concretions, which are ſometimes cemented together by an infiltration of quartz. When the concretions are very fine, the fracture is nearly compact; when the concretions are larger, the fracture is more or leſs ſplintery. Its fragments are indeterminately angular, blunt edged. It is tranſlucent. In its other characters it agrees with the firſt ſubſpecies.

The fine-grained with ſilvery mica and cream coloured felſpar, compoſes a granite that occurs near Schihallion in the central highlands of Scotland: the larger grained forms large blocks in argillaceous ſchiſtus, and other primitive rocks in Shropſhire. This latter becomes of a pure ſnow-white colour by calcination, and is largely employed in the manufacture of China-ware.

4 *Subſp.* Compact quartz.

Its colours are to the full as various as thoſe of rock cryſtal. It occurs in maſs, diſſeminated, in rounded fragments, alſo of particular ſhapes, ſuch as globular, tubercular, ſpecular, cellular, &c. It varies in luſtre from ſhining to glimmering, the former is generally vitreous, the latter is for the moſt part greaſy or pearly. Its fracture is coarſe ſplintery paſſing into minute conchoidal. Its fragments are indeterminately angular, not very ſharp-edged. It varies from tranſlucent at the edges to ſemi-tranſparent. In other particulars it agrees with the firſt ſubſpecies.

It occurs in every kind of rock, from the oldeſt to the moſt recent, forming an eſſential conſtituent of ſome, as granite and gneiſs, and compoſing veins and beds in others: ſometimes it is found in conſiderable blocks, but never forms entire mountains.

There are three varieties of compact quartz, which require to be deſcribed ſeparately.

Var. 1. Praſe.

Its colour is leek-green; it occurs in maſs. Its luſtre is gliſtening, between reſinous and vitreous. It is tranſlucent. It occurs at Brūtenbrun in Saxony, in a mineral bed, and appears to be a very intimate mixture of quartz and actynolite.

Var. 2. Milk or roſe quartz.

Its colour is pale roſe, paſſing into reddiſh, greyiſh and yellowiſh white. It occurs in maſs. It is gliſtening, with a greaſy luſtre. Its fracture is more or leſs conchoidal. It varies between ſemi-tranſparent and tranſlucent. It is ſuppoſed to be quartz coloured by manganeſe. It is capable of a high poliſh, and is formed into various ornaments. It occurs in a large grained granite at Rabenſtein in Bavaria, and is ſaid alſo to have been found in Finland.

Var. 3. Aventurine.

Its colour is yellowiſh red, or grey, greeniſh, or blackiſh. When held in the light it appears to be filled with ſilvery and yellowiſh ſpangles that reflect the rays of light with great brilliance. Theſe ſpangles have been taken by ſome mineralogiſts for mica, but according to others the appearance is produced only by the particular direction of its laminæ. It is ſuſceptible of a good poliſh, and is uſed for ſeal-ſtones and other ornaments. The fineſt aventurines come from Spain.

QUICKLIME. See LIME.

QUICKSILVER. See MERCURY.

QUINTESSENCE.

Properly, the fifth eſſence, or the reſult of five ſucceſſive diſtillations. The term is at preſent obſolete; but was uſed by the old chemiſts to expreſs the higheſt degree of rectification to which any ſubſtance can be brought.

R

RADICAL VINEGAR. See Acetous Acid.

RAGG. See Basalt.

REALGAR. See Arsenic, Sulphuret of.

REALGAR, Native. See Arsenic, ores of.

RECEIVER, or RECIPIENT. } Articles
RECIPIENT, Italian. }
of chemical apparatus, for an account of which ſee the Appendix.

RECTIFICATION.

This term implies the repetition of the proceſſes of diſtillation or ſublimation, generally with a leſs degree of heat than at firſt, in order thereby to purify the ſubſtances which are the ſubjects of them from all foreign matters with which they may be mixed. Thus alcohol is rectified by rediſtilling it at a gentle heat, by which it is ſeparated from the water and other impurities contained in common diſtilled ſpirits.

RED CHALK or REDDLE. See Iron, ores of, p. 587.

RED LEAD or MINIUM. See Lead, oxyds of.

RED SCHORL. See Titanium, ores of.

REDUCTION.

Is the decompoſition of a metallic oxyd ſo as to leave the metal in a ſtate of greater or leſs purity, and exhibiting the luſtre which is ſo eminently characteriſtic of metallic bodies. Reduction is for the moſt part effected by charcoal and a high temperature, either with or without the aſſiſtance of fluxes. For the various modes of reduction in actual practice, ſee the articles of the different metals.

REFINING Gold and Silver.

For a particular account of the method of purifying theſe metals, ſee the articles Assay, Gold and Silver.

REFRACTORY.

A ſubſtance that is either incapable, or even very difficult of fuſion, is ſaid to be refractory, ſuch are quartz, pure clay, platina, &c.

REFRIGERATORY.

An article of chemical apparatus, for a deſcription of which ſee the Appendix.

REGULUS. *Konig.* Germ.

The term in its moſt extenſive ſenſe means a metal in the proper metallic ſtate. Although a very convenient word, it is not much in uſe at preſent, being proſcribed by the chemical neologiſts. By the old chemiſts it was chiefly uſed as a diſtinctive appellation in thoſe caſes where a metal and one of its ores happened to be called by the ſame name. Thus the grey ſulphuret of antimony, was known by the name antimony, long before it was ſuſpected to contain a peculiar metal, hence when this diſcovery took place, the metal was called *Regulus of antimony*, to diſtinguiſh it from the ore from which it was procured. For a ſimilar reaſon the metals arſenic and cobalt were called Reguli of arſenic and cobalt.

RESIN. *Harze.* Germ.

This term is given to a very important claſs of vegetable ſubſtances of which there is a great variety of ſpecies, differing from each other in conſiſtence, colour, ſmell, and in ſome degree in chemical compoſition.

The origin of all the reſins is the ſame, that is, they exſude ſpontaneouſly, or are extracted by inciſions made in the bark of the reſinous trees, and moſt of them gradually harden by expoſure to air. A further portion of the ſame reſin may alſo be always extracted artificially from the tree that yields it, by chemical methods. Reſin is alſo very generally met with in certain parts of vegetables, though its quantity is ſo ſmall, or its combination with other conſtituent parts is ſo ſtrong as not to appear in its proper form till extracted by chemical analyſis. Thus the bark of the cinchona contains no inconſiderable quantity of reſin though none appears to the eye on mere inſpection, or (probably) could be extracted by inciſion through the living tree.

The chemical properties which are uſually underſtood to characterize a reſin, are the following: it is firſt ſoftened and then melted by heat, and when kindled it burns readily with a ſtrong and generally fragrant ſmell, with copious flame and ſmoke, and leaves ſcarcely any reſidue behind. It is inſoluble in water and moſt watery liquids, and is not *eaſily* acted on by acids or alkalies, except they are concentrated, and the action aſſiſted by heat or long digeſtion. But it readily and totally diſſolves in alcohol, forming a clear, but coloured, ſolution from which by far the greater part of the reſin is precipitated in a pulverulent form unaltered, by the addition of water, which immediately renders the ſolution opake and turbid. It is alſo ſoluble in ſulphuric ether, and in the fixed and volatile oils, particularly the latter.

But though all reſins agree in the qualities of inflammability, inſolubility in water, and ſolubility in alcohol, there are ſeveral other circumſtances which have uſually been employed to diſtinguiſh the claſſes of reſins.

Balſams according to the antient ſenſe of the word was certainly applied ſimply to thoſe reſins that always remained in a fluid or ſemin-fluid ſtate, ſuch as the Balſam of Capivi, of Mecca, of Canada, &c. and theſe appear to be reſins holding a ſuperabundance of eſſential oil, ſo that when diſtilled *per ſe* a vaſt quantity of oil ariſes, and a hard brittle reſin is left behind if the heat employed is only moderate. Thus turpentine, which is a natural balſam, yields by diſtillation abundance of the eſſential oil of turpentine; and common roſin (which is a true reſin) is left behind.

The term Balſam however has of late been injudiciouſly applied in the modern chemical nomenclature to thoſe two or three ſpecies of reſins that contain a notable quantity of *Benzoic acid*, as deſcribed under that article.

Gum reſins are natural mixtures of a true reſin with another ſubſtance apparently of the nature of gum and ſoluble in water. Hence if they are triturated with water, they remain ſuſpended in it in pretty intimate mixture for a conſiderable time, forming an opake emulſive liquor. By ſtanding, however, the reſin ſubſides, and the liquor becomes clear, but it retains the flavour and ſmell of the gum reſin, and leaves on evaporation a ſmall quantity of brown extractive matter. Gum-ammoniac is an example of this kind. This diſtinction however is not very preciſe, and is more uſeful in pharmacy than in pure chemiſtry.

There are ſome ſubſtances evidently reſinous in their nature and origin, but which have other peculiar properties that have cauſed them to be excluded from the liſt of reſins.

Camphor is of this kind, which poſſeſſes ſome diſtinctive characters that have already been fully deſcribed under that article.

Caoutchouc, copal, and perhaps amber alſo, appear to belong ſtrictly to the claſs of reſins, but each has ſome points in which it differs materially from them.

We ſhall refer our readers to the articles *Varniſh* and *Turpentine* for ſome of the moſt important individual reſins, and in this place only notice ſome chemical properties common to the whole claſs.

All the reſins ſink in water. Moſt of them are without taſte or only give a ſlight pungency when long chewed. When heated *per ſe* in a cloſe veſſel, they firſt give a conſiderable quantity of eſſential oil proportionate to the ſoftneſs and approach to liquidity of the reſin, after which, if the heat is raiſed, they yield an acidulous water, carburetted hydrogen, and carbonic acid, and a brilliant ſpongy coal is left. The reſins burn readily in the air, with much flame and a very denſe ſmoke, which latter carries with it a large quantity of very pure charcoal, that ſettles upon all the contiguous ſurfaces, covering them with a fine *lamp-black*. Much water is alſo generated during this combuſtion.

Reſins unite by melting, with ſulphur, and alſo with phoſphorus though with difficulty.[a] It is generally aſſerted that neither alkalies nor acids have any action upon reſin, neither inflaming nor oxydating them nor reducing them to a ſoap.[b] This however is found to be entirely a miſtake, for many of the acids, and the fixed alkalies act very powerfully upon theſe ſubſtances, as has been ſhewn by Mr. Hatchett in his valuable analyſis of gum lac,[c] and more lately in his experiments on the production of artificial tannin.[d] The former have been already mentioned under the article *lac*[c], and the latter we ſhall chiefly refer to *tannin*, but with a ſhort notice in this place of that part of theſe highly curious reſearches which more immediately refers to the properties of reſins.

Potaſh compleatly diſſolves reſin by long boiling, and carbonat of potaſh acts conſiderably upon it though much leſs perfectly. This ſolution is clear and of a ſaponaceous conſiſtence, and will bear dilution with water without becoming turbid, but on the addition of an acid the whole of the reſin ſeparates.

If a metallic ſolution in acid be added to the alkaline ſolution of the reſin, a curdy precipitate is formed, conſiſting of the reſin united moſt intimately with the metallic oxyd, which bears a ſtrong reſemblance to the ſimilar precipitates formed by adding a metallic ſolution to ſoap.

When ſtrong nitric acid is digeſted with reſin it is firſt converted into a pale orange-coloured porous brittle ſubſtance, after which a repeated abſtraction of the acid at a boiling heat, converts the reſin into a deep yellow viſcid ſubſtance, ſoluble both in water and alcohol, into a clear liquor, in which moſt of the reſinous properties are loſt. Very long continued digeſtion in the acid without heat will produce the ſame effect. Nitrous gas is produced in abundance during each diſtillation, and the ſtrength of the acid which comes over is diminiſhed, which ſhews that this change depends chiefly, if not entirely upon the action of the oxygen of the decompoſed acid. This deep yellow ſolution produces no effect on nitrat of lime thus ſhewing the abſence of oxalic acid. With acetited lead it gives a copious yellow precipitate, and with a ſolution of iſinglaſs or any other animal gelatin it produces a denſe yellow precipitate, inſoluble in boiling water; and reſembling in every other property the precipitate produced by galls, catechu, and other native vegetable *tannins*. This laſt effect however is not produced unleſs the reſin has been long and repeatedly treated with nitrous acid, whereas the reſinous properties are loſt at an earlier period of the action of this acid. On the other hand, if the reſin has been previouſly charred to a ſlight degree either by heat or by ſulphuric acid, the artificial tannin is produced much more ſpeedily. Hence Mr. Hatchett ſuppoſes that this tanning ſubſtance is formed in conſequence of part of the oxygen of the nitric acid combining with the hydrogen of the reſin ſo as to produce water, and a proportionate quantity of carbon being thus denuded it is capable of yielding the tannin by the ſubſequent action of the acid. It ſhould be added too, that the ſame ſubſtance is produced in much greater abundance by the action of nitric acid on charcoal alone, which thus may be made to yield more than its own weight of tannin.

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[a] Fourcroy.

[b] Ibid.

[c] Phil. Tranſ. for 1804.

[d] Ditto for 1805 and 6.

It has been mentioned that no oxalic acid is formed by the action of the nitric acid on the pure reſins, and this appears to be a very good characteriſtic mark of theſe bodies, ſince moſt other vegetable principles yield it in greater or leſs abundance. This is particularly the caſe with mucilage and extract of every kind, and hence the natural *Gum-reſins* when treated with nitric acid afford a ſmall quantity of oxalic acid, which may ſerve to diſtinguiſh them from the true reſins. This production of oxalic acid appears abſolutely to prevent the formation of the artificial tannin, ſo that none of the latter could be obtained from gum-arabic, tragacanth, and other mucilages. The preſence of the benzoic acid alſo in ſome degree counteracts the formation of tannin, and hence leſs of it is produced from gum benzoin, and balſam of tolu, than from the ſimpler reſins.

When concentrated ſulphuric acid is poured upon any of the ſolid reſins reduced to fine powder, it diſſolves them in a few minutes and forms a tranſparent yellowiſh brown ſolution of the conſiſtency of a viſcid oil. This proceſs ſeems at firſt to be a ſimple ſolution, but in a little time (eſpecially if warmth be uſed) the colour of the ſolution progreſſively deepens, ſulphureous acid gas exhales, and at length the whole becomes a thick fluid, of an inky blackneſs. A ſimilar effect is produced by the action of this acid upon the liquid reſins. If the acid is poured on common turpentine it diſſolves it almoſt immediately, and if a portion of this ſolution be poured into cold water, the turpentine is precipitated in a ſolid brittle ſtate like common yellow roſin. But if a ſecond portion is thus decompoſed after the interval of an hour or two the precipitated reſin is of a dark brown; and a third portion after the interval of four or five hours is quite black. If the digeſtion be continued for ſeveral days, the production of ſulphureous gas ceaſes, and the turpentine (or whatever reſin be uſed) is converted into a black porous coal, which yields no reſin to alcohol, and amounts in general to from a third and more to a fifth of the reſin employed. The quantity of coal produced by ſulphuric acid far exceeds that which is afforded by the ſimple application of heat, ſince theſe reſins when heated ſtrongly *per ſe* in cloſe veſſels leave behind ſcarcely a hundreth of their weight of coal. If ſeparate portions of the reſin procured by dropping the ſulphuric ſolution in water after different periods of digeſtion are merely diſſolved in nitric acid, the artificial tannin is only found in thoſe ſolutions in which the reſin is actually or nearly charred. The coal obtained from the reſin by means of ſulphuric acid is not only in much greater quantity than that produced by ſimple heat, but differs from it conſiderably in texture and appearance, being when obtained by the humid proceſs, ſhining, hard, and ſometimes irideſcent; whereas that produced by calcining the ſame reſins in cloſe veſſels is ſpongy and light. The former kind burns like ſome of the mineral coals with great difficulty, but the latter like common charcoal. The great difference in the proportional quantity of coal, is ſhewn by the following ſtatement: 100 grs. of common reſin afford by ſulphuric acid 43 of coal, of which after expoſure to a red heat 30 ſtill remain, but the ſame quantity yields by calcination in cloſe veſſels only $\frac{3}{4}$ of a grain.

100 grains of maſtich afford 66 grs. of coal, by the firſt proceſs, but only 4½ by the ſecond.

100 grains of amber yield 56 grs. of coal by ſulphuric acid, but only 3½ by calcination.

On the other hand the difference between theſe reſpective quantities of coal from the mucilages is much leſs.

The acetic acid diſſolves the true reſins even without heat when digeſted with them for a conſiderable time, and on the addition of water the whole is again ſeparated, apparently unchanged. This latter method is uſeful in analyſis to ſeparate reſin and gluten, both of which are ſoluble in acetic acid, but the latter remains in ſolution when water is added. As the acetic acid does not (like the ſulphuric and nitric) alter the reſin, it affords a very uſeful re-agent in chemical analyſis.

A very ſtrong reſemblance exiſts between the reſins and the eſſential oils in many of their moſt important properties, whence ſome chemiſts have been diſpoſed to conſider theſe oils as the origin of reſins. When an eſſential oil is expoſed to the air, much of it is entirely evaporated, but the portion which is left gradually thickens, water appears on the ſurface, and the oil loſes its volatility, and with it much of its ſmell, and gradually approaches to the ſtate of reſin. This change has already been mentioned under the article OIL *Eſſential* (page 183) and alſo the method of reſtoring a part of this oil by means of ſulphuric ether into its original ſtate, and the perfect reſinification of the remainder.

Nitric acid alſo converts the eſſential oils into a reſin, where the mutual action of the two ſubſtances (which is very rapid and intenſe) is moderated by dilution, or very gradual affuſion of the acid in ſmall quantities. This change (which is alſo mentioned in the ſame article, p. 184) takes place very remarkably with oil of amber, which reſembles the eſſential oils in many properties. If about its own bulk of fuming nitrous acid is poured on it gradually, much heat is excited, and nitrous gas is given out, though the action is altogether leſs than with the eſſential oils, and in ſome hours the whole is reſolved into a yellow acid liquor, weak of acid compared to the quantity employed, on which ſwims a tough yellow reſin intenſely bitter, aromatic, inſoluble in water, but which diſſolves in alcohol, and is precipitated from it by water. This ſingular ſubſtance leaves a muſky ſmell when a little of its ſolution is ſuffered to dry in the air, and it has been introduced into medicine under the name of *Artificial Muſk*.

We may conclude this article by a ſhort enumeration of the moſt important of the true reſins, the gum reſins, and the ſubſtances, not prepared by art, to which a reſinous nature has been uſually attributed.[a] To attempt to enumerate them all would be endleſs, as there are few plants from which a ſpecies of reſin may not be extracted by art, and even the number of thoſe that exſude ſpontaneouſly is extremely great.

Though no claſſification will correctly correſpond with their chemical properties, the limits between the reſins and gum-reſins not being very preciſe, we may uſefully arrange the greater part of theſe ſubſtances under the head of *Liquid Reſins or Balſams, Solid Reſins, and Gum Reſins*. The two firſt claſſes are entirely or almoſt entirely inſoluble in water, except they contain benzoic acid, but totally yield to alcohol. Diſtillation with water extracts from the liquid reſins a large quantity of eſſential oil, and leaves a reſidue much reſembling the ſolid reſins. The gum-reſins are partly ſoluble in water and partly in alcohol.

LIQUID RESINS.

1. *Turpentines*. Under this name we may include all the liquid reſins exſuding from the different ſpecies of pine, which from their importance in the arts and the immenſe conſumption of them will be ſeparately deſcribed under the article *Turpentine*. They all yield abundance of the limpid eſſential oil of turpentine when diſtilled, and by different modes of preparation furniſh ſeveral varieties of *roſin*, *pitch*, *tar*, &c. There are at leaſt four ſpecies of turpentines commonly known in the ſhops, the *Chio*, *Venice*, and *Common Turpentine*, and the *Canada Balſam*.

2. *Balſam of Capivi or Copaiba* is a clear yellowiſh reſinous juice, about the conſiſtence of thin treacle, which flows in conſiderable quantity from inciſions made in the bark of a large tree of South America, the *Copaifera Officinalis*.

This balſam has a very agreeable ſmell and a pungent bitteriſh taſte. It grows ſtiffer by long keeping but never concretes into a ſolid. It diſſolves totally in alcohol. When diſtilled with water it yields nearly half its weight of eſſential oil, and a brittle inodorous reſin is left. It appears therefore to be a natural combination, ſimply of reſin and eſſential oil.

3. *Balſam of Mecca, Opobalſam, or Balſam of Gilead*. This is a liquid reſin which exſudes from the *Amyris Opobalſamum*, a ſmall evergreen tree that grows in many parts of the Levant, and alſo in great perfection on the ſhores of the Red Sea. It bears an extremely high price among the Turks, who employ it chiefly as a coſmetic, and it is ſcarcely ever found genuine in any other part of Europe.

It is moderately fluid, of a yellowiſh white colour, very fragrant, and of a ſlightly bitter and acrid taſte. Its chemical properties cloſely reſemble thoſe of the laſt mentioned ſpecies, and it is only mentioned in this place on account of the extravagant value which the Turks ſet upon it, which is far beyond that of all the other aromatics.

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[a] Murray Apparatus Medicam. Lewis Materia Med. &c. &c.

4. *Balſam of Peru.* This is a dark brown balſam of the conſiſtence of thin honey obtained from the *Myroxylon Peruiferum* (as it is ſaid) by boiling the twigs and bark in water, and when cold, the balſam ſwims at the top of the liquor and is ſkimmed off. There appears to be two ſpecies of this balſam, the *white* and the *brown*, but the latter is the only one commonly known.

This juice has a very fragrant ſmell and pungent taſte. It is entirely immiſcible with water and with the fixed oils, but diſſolves in the eſſential oils and in alcohol. When this balſam has long remained at reſt in any veſſel, it depoſits cryſtals, from which the benzoic acid may be obtained by ſublimation.

By diſtillation with water this balſam yields $\frac{1}{16}$ of its weight of an eſſential oil, of a reddiſh colour, and a pungent taſte. This oil probably alſo contains benzoic acid. When compleatly charred by ſulphuric acid, Mr. Hatchett found 100 grs. to yield 64 grs. of mere charcoal. A compound tincture of this balſam forms the common *Friar's Balſam*, uſed as an application in cuts and ſlight wounds.

5. *Balſam of Tolu.* This juice flows from inciſions made in the trunk of the *Toluifera Balſamum*, a large tree reſembling the pine, which abounds in the province of Tolu, in South America. It is of a yellowiſh brown colour, and, when freſh, of a thick tenacious conſiſtence, but by age it hardens ſo as to be moderately brittle in cold weather.

This balſam has a moſt fragrant ſmell, more ſo than moſt of the reſins, ſomewhat reſembling lemons. When chewed it clings to the teeth, and at firſt gives very little taſte, but after a time it leaves an agreeable pungency in the mouth. When kindled it burns with a copious flame and ſmoke (like all the other reſins) but this is accompanied with a very pungent fragrant vapour which excites coughing, and is owing to the volatilization of the benzoic acid that this balſam contains in ſome abundance, though in much leſs proportion than the gum benzoin. When this balſam is boiled with water it melts, and ſettles at the bottom of the veſſel, and appears to remain there unaltered, but the water without loſing its tranſparency becomes highly fragrant and pungent, and contains a notable quantity of benzoic acid. This acid may alſo be procured from it by the ſame methods by which it is extracted from the gum Benzoin, as deſcribed under that article.

Balſam of Tolu is totally ſoluble in alcohol, and it is entirely ſeparated from this menſtruum (the benzoic acid excepted) by water. If the ſolution is not too concentrated this precipitated balſam remains for a time ſuſpended in the liquor and gives it a milky appearance. By diſtillation this balſam yields an eſſential oil and benzoic acid. A hundred grains of the balſam charred by ſulphuric acid, gave fifty-four grains of charcoal.

6. *Liquidambar*, or *Liquid Storax*. This is a reſinous juice, which flows from the trunk of the *Liquidambar Styraciflua*, a tree reſembling the maple, found in Virginia and Mexico. This balſam is of the conſiſtence of honey, reddiſh brown, nearly tranſparent, of an acrid unctuous taſte and a fragrant ſmell. It is ſeldom ſeen, and has not been much examined.

Solid Resins.

7. *Gum Anime.* This reſin, which is very rarely met with, exſudes from the trunk of the *Hymenæa Courbaril*, a large tree growing in Brazil and New Spain. It is brought over either in ſmall roundiſh tears, or in larger maſſes, with the ſurfaces covered with a white powder. The colour is yellowiſh white and pellucid, it is very brittle, and gives a ſhining fracture. It reſembles copal in appearance, but is readily diſtinguiſhable from it (among other things) by being eaſily and totally ſoluble in alcohol, which copal is not, without much difficulty and particular management. This reſin has very little taſte. It is inſoluble in water, but forms a grateful yellow tincture with alcohol, which has a bitteriſh pungent taſte. Diſtilled with water it gives a very ſmall quantity of eſſential oil. The natives of the countries whence it is procured chew it, but it is never uſed in Europe.

8. *Benzoin.* This reſin, which contains more of the benzoic acid than any other ſubſtance, has already been deſcribed under this article.

9. *Dragon's Blood.* The origin of this valuable reſin is not preciſely known, but it appears to be obtained from ſeveral large trees growing in many parts of the Eaſt Indies and the Indian Archipelago, of which the moſt known are the *Calamus Rotang*, and *Pterocarpus Draco*. This reſin is very largely mixed and adulterated ſo that the ſamples to be found in

the different ſhops, often have ſcarcely any other reſemblance than in colour. The beſt ſort of dragon's blood is found in irregular roundiſh pieces about the ſize of a walnut, often wrapped in palm leaves, and of a deep uniform dull red colour, without ſmell or taſte. When broken, its texture appears homogeneous, but evidently cellular. If a little of it is rubbed much in a mortar the colour brightens, and ſomewhat approaches that of vermillion.

Pure dragon's blood is entirely inſoluble in water, but totally ſoluble in alcohol, forming a tincture of a fine blood-red colour. It burns with a bright flame, and readily conſumes leaving only a ſmall portion of a white aſh. When charred by ſulphuric acid, 100 grs. leave 48 grs. of coal.

Dragon's blood is ſoluble in the eſſential oils, and alſo in the fixed, giving them a fine red colour. This reſin is largely uſed in *Varniſhing*, (which ſee) in lacquering, and painting, where a full bodied deep red is wanted.

10. *Gum Elemi.* This reſin comes over from South America in ſemi-pellucid yellowiſh maſſes generally wrapped up in leaves, and viſibly contaminated with bits of twigs and bark, friable in the fingers, ſoftening by heat, of a fragrant ſmell and bitteriſh taſte. The tree that yields it is ſuppoſed to be the *Amyris Elemifera*.

Water diſſolves only about $\frac{1}{16}$ of this reſin, and the remainder is ſoluble in alcohol.

11. *Gum Hederæ* is a reſin which exſudes in hot countries from the ſtalks and leaves of the ivy, (*Hedera Helix*.)

It appears in hard compact maſſes, reddiſh brown externally, internally of a bright yellow, nearly opake, brittle, and with a gloſſy vitreous fracture. The ſmell is agreeable when rubbed, the taſte ſlightly aſtringent. It is not entirely ſoluble either in water or alcohol, ſo that in ſtrictneſs it ought hardly to be called a true reſin. It is little known, and has not been carefully examined.

12. *Labdanum or Ladanum.* This reſin exſudes ſpontaneouſly from the leaves and branches of a fragrant ſhrub (*Ciſtus Creticus*) which grows abundantly in the dry mountainous regions of the Iſle of Candia, Syria, and other parts of the Levant. Ladanum is a black, hard, heavy, reſinous maſs, rough externally, and in fragments, and its fracture ſhews diſtinct ſparkling particles. When chewed it gives a gritty feel to the mouth, and a bitteriſh taſte, but does not diſſolve. The ſmell is fragrant. When digeſted with water it imparts its grateful ſmell, but does not ſenſibly diſſolve therein. By diſtillation it gives a fragrant eſſential oil, and a taſteleſs brittle reſin remains. Alcohol diſſolves all the reſin, and always ſhews in the undiſſolved reſidue a conſiderable quantity of ſand and other impurities.

13. *Maſtich.* This very valuable reſin is procured from the *Piſtacia Lentiſcus*, a tree that grows to ten or twelve feet high, and is cultivated in many parts of the Levant, particularly in the iſland of Chio.

The beſt maſtich is in the form of ſmall roundiſh tears, hard and brittle, of a faint yellow colour, nearly tranſparent, with a light but pleaſant ſmell, and little or no taſte. When chewed it ſoftens in the mouth, and excites a conſiderable flow of ſaliva. It is nearly inſoluble in water, but gives it a pleaſant flavour when boiled with it. Alcohol and the eſſential oils diſſolve maſtich entirely, forming a clear light-yellow tenacious ſolution, which either alone or with other reſins is much employed in varniſhing and other arts. When charred by ſulphuric acid, 100 grains afford 66 of charcoal.

14. *Sandarac.* This reſin exſudes from the bark of ſeveral kinds of Juniper, and concretes in nearly pellucid yellowiſh tears of a pleaſant ſmell, and ſcarcely any taſte. It is compleatly ſoluble in alcohol, and in oils fixed or eſſential, and is much uſed in varniſhing.

15. *Tacamahacca.* This reſin is obtained from the *Fagara octandra*, a tree found in many parts of South America. There are two ſorts of this reſin; the beſt is collected in gourd ſhells, and is unctuous and ſoft, of a greeniſh yellow colour, a delightful ſmell approaching to that of lavender, and a bitteriſh aromatic taſte. It is ſeldom uſed.

16. *Styrax*, or *Storax*, is a very fragrant reſin procured from the *Styrax officinalis*, a middling ſized tree, a native of Aſia. There are two ſorts of this reſin; the Styrax calamita, compoſed of reddiſh brown maſſes of a waxy conſiſtence, and free from viſible impurities. The other, which is by much the commoneſt ſort, is ſo largely adulterated with ſaw-duſt, that it looks rather like a maſs of ſaw-duſt ſomewhat agglutinated by means of a ſoft clammy reſin. Common ſtyrax infuſed in water gives it a golden colour, a fragrant ſmell, and a ſlight balſamic taſte. Diſtillation with water ſtill further impregnates this liquid with the ſame qualities of ſmell and taſte, and contains *benzoic* acid, which may be extracted in the way mentioned under this article. When ſtyrax is diſtilled *per ſe* it yields

along with an empyreumatic oil ſome cryſtallized flowers of benzoin. Alcohol diſſolves all the true ſtyrax from the impure maſs. In flavour and, when pure, in other properties, this reſin ſtrongly reſembles the balſam of Tolu.

Gum Resins. Theſe ſubſtances, as already mentioned under this article, are not entirely ſoluble in either water or pure alcohol, ſingly, but compleatly ſo in a mixture of the two. Many of them have very ſtrong ſenſible properties, and they are altogether much more active when uſed medicinally than the reſins. When rubbed with water, they form a thick emulſion, from which moſt of the reſinous part ſeparates by repoſe.

The gum-reſins are principally, though not entirely, uſed in medicine.

17. *Aſafœtida.* This gum-reſin is the dried juice of a large umbelliferous plant, (*Ferula aſafœtida,*) which grows in the mountains of Perſia and Arabia. It is collected by cutting the mature plant a little above the ground, which cauſes a quantity of white juice to exſude on the cut ſurface of the ſtock, that ſoon concretes into a browniſh ſoft gum. This is removed, a freſh ſurface is made on the ſtalks by cutting it down for an inch or two, and more of the juice is collected, till after a time the whole is exhauſted, and the ſtalk dies.

Aſafœtida is brought to us in irregular maſſes moſtly of a browniſh colour approaching to red, and involving ſmaller lumps that are nearly white. It has a very ſtrong fetid ſmell like garlic, extremely permanent and diffuſive, its taſte is nauſeous and bitteriſh. If rubbed with water it entirely reſolves into a milky emulſion, from which after ſtanding for ſome time moſt of the reſinous part ſubſides, leaving a clear ſupernatant liquor containing much gum in ſolution. Pure alcohol diſſolves only the reſinons part, and makes a clear yellow ſolution. Dilute alcohol diſſolves the entire reſin and forms a browniſh, rather turbid tincture. Water diſtilled off aſafœtida riſes ſtrongly impregnated with its peculiar ſmell. A hundred grains charred by ſulphuric acid yield 58 grs. of charcoal.

18. *Galbanum* is the concrete gummy-reſinous juice of an umbelliferous plant of Ethiopia, (*Bubon galbanum,*) and is brought over in pale ſemi-tranſparent, ſoft, tenacious maſſes, intermixed with clear white tears of the ſame reſin. This juice has a ſtrong unpleaſant ſmell, and a bitteriſh, warm taſte. When rubbed with water it diſſolves into a milky emulſion, and has all other chemical properties of the gum reſins.

19. *Gum Ammoniacum,* a gum reſin brought from the Eaſt Indies, compoſed of ſmall white lumps or tears, more brittle than moſt of the other gum-reſins, and eaſily reduced to fine powder in cold weather. It unites perfectly with water into a milky emulſion, and water and alcohol ſeparately diſſolve only a portion of the gum. It is ſometimes employed in a ſmall degree in the compoſition of cements and varniſhes. A hundred grains charred by ſulphuric acid give 58 of charcoal.

20. *Opopanax* is a ſtrong-ſmelling gummy reſinous juice procured from the *Paſtinaca opopanax,* and brought from Turkey and the Eaſt Indies in ſmall round drops or irregular lumps of a reddiſh yellow colour. It mingles perfectly with water, and agrees in chemical properties with the other gum reſins.

21. *Sagapenum,* is a fetid gum much reſembling aſafœtida, but weaker in ſenſible properties, it is brought from Alexandria, in ſoft irregular maſſes ſticking to the fingers when handled. In chemical properties it agrees very cloſely with aſafœtida.

22. *Olibanum.* A gum reſin brought from Turkey and the Eaſt Indies, in large roundiſh lumps, ſemi-pellucid, and when of the pureſt kind, of a ſlight yellow colour. When chewed it has a bitteriſh pungent taſte, and makes the ſaliva milky. The ſmell is moderately ſtrong, and not diſagreeable. When laid on a hot iron it burns with a ſtrong, penetrating, and rather fragrant ſmell, and is ſuppoſed to have been uſed by the ancients for incenſe.

23. *Gamboge.* For a deſcription of this valuable gum, ſee the article *Gamboge.*

24. *Euphorbium* is a juice procured from a plant of this name, brought chiefly from Barbary, in drops of an irregular form of a pale yellow, and brittle. This gum-reſin has but little ſmell, but the taſte is one of the moſt biting and acrid of any known ſubſtance, and the effect on the organs remains for a conſiderable time. It conſiſts of about equal parts of gum and reſin.

25. *Myrrh.* This gum-reſin exſudes from a tree which grows in Abyſſinia and many parts of Arabia, but is little known. It comes over in rounded pieces of various ſize, and ſtill more varying in colour, conſiſtence, taſte, and ſmell. The beſt ſort is ſemi-tranſparent, friable, unctuous to the touch, of an uniform light or reddiſh yellow colour, of a ſtrong but not ungrateful ſmell, and a ſlightly pungent and very bitter taſte. It burns with ſome difficulty. It compleatly diſſolves in boiling water when previouſly pulverized, but on cooling, a yellow

reſinous ſediment falls down. The ſupernatant liquor evaporated nearly to dryneſs yields a ſaponaceous extract, which retains much of the flavour of the myrrh. Alcohol digeſted with myrrh forms a very ſtrong-ſmelling, intenſely bitter tincture, of a very fine golden yellow colour, which is made turbid by the addition of water.

Guaiacum. This ſubſtance has uſually been reckoned among the perfect reſins, but late experiments (though they are not compleat,) ſhew that it has ſome very peculiar properties, ſo that it cannot be claſſed properly either with the gums or reſins.

This gum is procured from the *Guaiacum wood*, or *Lignum vitæ*, which is a very hard, ponderous wood, obviouſly abounding with reſin, and as it were ſoaked in it, ſo that it has a peculiar greaſy feel, and a very ſtrong and peculiar ſmell when rubbed.

Gum guaiacum is brought over in irregular maſſes, eaſily friable, of a duſky green colour. It is in ſome degree tranſparent, and it breaks with a vitreous fracture. When pulverized, it is of a grey colour, but becomes green on expoſure to air.[a] It melts when heated, and gives a very pungent aromatic odour. The ſmell is fragrant; it gives ſcarcely any taſte in the mouth, but when ſwallowed, it excites a ſtrong burning ſenſation in the throat. Mr. Hatchett has obſerved that guaiacum, though apparently a pure reſin, differs from all the pure reſins in giving much oxalic acid by the nitric, and in yielding ſcarcely any artificial tannin with the nitric acid. Mr. Brande has ſince given an intereſting analyſis of this ſubſtance.[b]

When pulverized guaiacum is digeſted in a moderate heat in diſtilled water, an opake ſolution is formed, which becomes clear on paſſing the filter. This liquor is of a greeniſh brown colour, and a ſweetiſh taſte. The muriats of alumine and tin, and nitrat of ſilver, all cauſe a brown precipitate, and when the liquor is evaporated an *extract* is left. One hundred grains of guaiacum yield about 9 grs. of this extract, which alſo contains ſome ſalt of lime, as ſhewn by the oxalic acid.

Alcohol diſſolves guaiacum with eaſe, leaving about 5 per cent. of extraneous matter undiſſolved. This ſolution is of a deep brown colour, and is decompoſed by water, which ſeparates the reſin and leaves the liquor of a milky hue. If muriatic acid is added to the alcoholic ſolution, the reſin at firſt ſeparates, which an exceſs of the acid rediſſolves. The addition of nitrous ether to the tincture and ſubſequent dilution with water, cauſes the reſin to precipitate, which ſoon acquires a fine *blue* colour,[c] and this change of colour appears characteriſtic of the reſin of guaiacum, and has been employed as a means of detecting any adulteration. Liquid oxymuriatic acid added to the tincture alſo precipitates the reſin immediately of the ſame blue colour.[d] Acetic acid cauſes no precipitate, the reſin being readily ſoluble in this acid. Nitric acid diluted with one fourth of its weight of water, turns the tincture green, and gives a green precipitate after ſtanding ſome hours, but the colour ſoon changes to blue, and afterwards to brown.

Alkalies do not cauſe any precipitation in the tincture.

The guaiacum in ſubſtance ſhews the following effects with the different reagents.

Sulphuric ether diſſolves it though leſs abundantly than alcohol.

Sulphuric acid acts on it nearly as on the other reſins, and finally chars it, leaving 58 grs. of coal from 100 of the reſin.[c]

Nitric acid acts upon it in a peculiar manner: 100 grs. of guaiacum were added to 2 oz. of this acid of 1.39 ſp. gr.[f] the reſin at firſt became of a dark green colour, a violent effervescence was excited with the production of much nitrous gas, and the whole was diſſolved without the aſſiſtance of heat. This ſolution, left at reſt for ſome hours, depoſited cryſtals of oxalic acid. In this laſt circumſtance, and in the ready ſolubility in cold nitric acid, guaiacum differs eſſentially from the other reſins.

Dilute nitric acid acted ſomewhat differently, and diſſolved only part of the guaiacum, and the remainder was converted into a chocolate brown ſubſtance, apparently the ſame as that produced by adding the ſame acid to the tincture after it has paſſed through the changes of green and blue. This brown ſubſtance now more compleatly reſembles the true reſins, being equally ſoluble in alcohol and ether, and inſoluble in water. If this is further decompoſed by nitric acid, in the way mentioned by Mr. Hatchett, it is converted into artificial tannin.

The alkalies, pure and carbonated, diſſolve guaiacum with eaſe.

RETORT.

An article of chemical apparatus, for an account of which ſee the Appendix.

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[a] Murray, Appar. Med.

[b] Phil. Tranſ. for 1806.

[c] Monch, in Crell's Journal, or Murray, Appar. Med. vol 3.

[d] Brande.

[e] Hatchett.

[f] Brande.

RHODIUM. See Platina.

ROCHELLE SALT. See Tartrite of Potash and Soda.

ROCK CRYSTAL. See Quartz.

ROCK SALT. See Muriat of Soda.

ROSES, Attar of. See Oils vegetable, eſſential.

ROSIN. See Turpentine.

ROTTEN-STONE. See Tripoli.

RUBY. See Spinel.

RUBY oriental. See Corundum.

RUBY OF ANTIMONY. See Antimony.

RUTHIL. See Titanium, ores of.

S

SACCHARUM SATURNI, or Sugar of Lead. See Lead, acetite of.

SACCHOLACTIC ACID. See Milk, p. 100. and Mucilage, p. 112.

SAFFLOWER. *Carthamus, or Baſtard Saffron.*

This plant, the flower of which is employed in dyeing and colouring, is cultivated in Spain and in many parts of the Levant,[a] from which it is chiefly imported.

This dyeing material contains two colouring matters, a yellow and red, the former of theſe alone is ſoluble in water and is comparatively of little value, the latter is ſoluble in alkalies and precipitated thence by ſeveral acids and forms a beautiful roſe-red pigment. This is partly uſed for ſilk dyeing, but the great conſumption of it is in the *rouge* ſo celebrated as a coſmetic, and of which it forms the eſſential ingredient.

To prepare the carthamus for this purpoſe it is neceſſary firſt to extract the yellow portion, which is done by tying the plant in a linen bag, and then waſhing it inceſſantly with water, uſing much ſqueezing and rincing till the water paſſes off colourleſs. The reſidue in the linen bag now conſiſts of the fibrous part of the plant and of the valued red fecula, which laſt however is in very ſmall quantity. This is extracted by digeſting the waſhed carthamus in a ſolution of carbonat of ſoda, (without applying artificial heat which would impair the colour,) and this gives an orange yellow alkaline ſolution, which on ſaturation with acids turns red, and gradually depoſits a beautiful red fecula which is the pigment in queſtion. Lemon juice is the acid preferred. But as the colour of this red fecula is extremely intenſe it will bear dilutions, which is done chiefly by rubbing it with finely powdered talc, in different proportions.

Alcohol will alſo diſſolve the red part of carthamus; and after the yellow portion has been extracted by water, a fine red tincture is made by digeſting the reſidue in alcohol.

On account of the high price of carthamus it is ſeldom if ever employed except for giving a finiſhing gloſs to dyed ſilks, and for the preparation of rouge. Alkalies of every kind immediately alter the colour to an orange yellow, again reſtorable by acids.

SAFFRON OF MARS. See Iron, p. 613.

SAHLITE. *Sahlit*, Wern. *Malacolithe*, Hauy.

Its colour is between greyiſh green and pale leek green. It occurs in maſs, and cryſtallized in ſix-ſided priſms. It is moderately ſhining with a waxy luſtre. Its longitudinal fracture is lamellar in three directions. Its fragments are often rhomboidal. It is tranſlucent on the edges; its hardneſs is about equal to that of glaſs. It is very ſmooth to the touch, and is eaſily frangible. Sp. gr. 3.23.

It is fuſible before the blow-pipe with difficulty into a porous glaſs. Its component parts, according to Vauquelin, are

53.	Silex
20.	Lime
19.	Magneſia
3.	Alumine
4.	Oxyds of iron and mangeneſe
99.	

This mineral was firſt diſcovered in the ſilver mines of Sahla in Sweden, it has ſince been found at Buoen near Auen in Norway.

SAL AMMONIAC. *Muriat of Ammonia. Salzaures ammoniak.* Germ.

This neutral ſalt, conſiſting of muriatic acid and ammonia, in a ſtate of mutual ſaturation, was not unknown to the ancients. In the time of Pliny it was imported into Europe from Egypt, and continued to be furniſhed by the ſame country to the various States of modern Europe, till within the laſt fifty or ſixty years.

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[a] Berthollet Elemens de la Teinture. Beckmann Comment. Gotting. vol. 3 and 4. Dufour An. Chem. Tom. 48.

It has alſo been prepared in India (probably in the ſame manner as in Egypt) from time immemorial. Before treating of the properties of this ſalt we ſhall give an account of its manufacture, firſt in Egypt, and then in the various countries of Europe.

[a]On account of the great want of wood in Egypt the principal fuel of the country is compoſed of the dung of camels, cows, and other domeſtic graminivorous quadrupeds, mixed up with chopped ſtraw and dried in the ſun. The ſoot produced by the combuſtion of this fuel is the material from which ſal ammoniac is prepared, by ſublimation. The veſſels made uſe of on this occaſion, are very thin globular glaſs balloons, with a ſhort neck terminating in a mouth about 1½ inch in diameter. The largeſt balloons are about 36 inches acroſs, but they are of very various ſizes, being capable of containing when three-quarters full, from 12 to 50 lbs. of ſoot. In order to ſecure them as much as poſſible from breaking during the proceſs, they are coated with a mixture of mud depoſited by the Nile, and chopped ſtraw.

It has been affirmed by the Jeſuit le Pere Sicard and ſome others, that the ſoot is mixed with a certain proportion of common ſalt and camels'-urine, but this appears to be a miſtake; being abſolutely contradicted by the moſt accurate enquirers. From theſe it appears that no other ingredient is made uſe of but ſoot, with which, moderately preſſed down, the balloons are filled to within about four finger's breadth of the neck. The veſſels thus charged are arranged, to the number of 60 or 70, in an oblong furnace of brick, and ſecured with clay ſo that their necks alone are in contact with the external air. The furnace is now very gradually heated by means of ſtraw for the firſt three or four hours, and afterwards with a mixture of ſtraw and the common fuel of the country, viz. dried dung. In the courſe of ſix or ſeven hours a thick ſomewhat acid empyreumatic ſmoke begins to riſe out of the balloons, and continues for about fifteen hours. The ſublimation of the ſal ammoniac commences three or four hours before the ſmoke ceaſes, and continues from fifteen to forty hours, according to the ſize of the balloon, without any further care being required than to regulate the fire properly, and to paſs an iron rod occaſionally down the necks of the balloons to prevent them from being clogged up by the ſalt as it riſes, and thus producing an exploſion. When the ſublimation ceaſes, the fire is allowed to go out, and the veſſels as ſoon as they are ſufficiently cool are removed from the furnace and broken; the cake of ſal ammoniac, which occupies their upper part, is in the form of a very ſhallow baſon, and weighs on an average ſomewhat more than ⅐ of the ſoot employed; it has generally a yellowiſh white tinge and is apt to be fouled with a little charcoal, eſpecially if the heat has been too great.

The proportion of ſalt from a given quantity of ſoot is liable however to conſiderable variation: it is found that the dung of the ſame animal affords a ſoot much richer in ſalt when it is fed on freſh vegetables than on hay and other dry food. There is beſides a great difference in the ſoot from the dung of different animals ſimilarly circumſtanced as to food. According to Mr. Granger, the Egyptian ſal ammoniac makers eſteem the ſoot of cow-dung when the animal is fed on graſs, to be by far the beſt, 26 lbs. of this affording no leſs than 6 lbs. of ſalt. According to Haſſelquiſt, however, the ſoot from the dung of goats and ſheep is in the higheſt eſtimation.

In this very ſimple manufacture, the ſal ammoniac appears to exiſt ready formed in the ſoot, and the action of the heat is confined to the mere ſeparation of the ſaline from the other ingredients. The ſoot itſelf is of a deep black colour, has very ſenſibly the taſte of ſal ammoniac, and when ſtrongly heated gives out a ſulphureous odour.

In Europe, where dung is employed to better purpoſe than for fuel, the manufacture of ſal ammoniac is a much more complicated proceſs, eſpecially when carried on in the beſt and moſt economical manner. A kind of intermediate method however is practiſed with ſucceſs in ſome eſtabliſhments in the Netherlands, of which the following are the principal details.[c]

A kind of fuel capable of furniſhing ſal ammoniac by its combuſtion, is firſt prepared, the ingredients of which are

25 parts by meaſure of pulverized pit coal
5 do. ———— of common chimney ſoot
2 do. ———— of clay

To theſe is added a ſaturated ſolution of common ſalt in ſufficient quantity to bring the whole to a conſiſtence for being moulded into balls. The balls are of an oval form, and after being dried in the air are ready for uſe.

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[b] Lemére in Mem. de l'Acad. des Sciences, 1720, p. 191. Granger in ditto, 1735, p. 107. Haſſelquiſt in Phil. Tranſ. vol. LI. p. 504.

[c] Journ. des Mines, No 10, p. 3.

The apparatus for collecting the ſoot produced by the combuſtion of this fuel, conſiſts of a brick furnace communicating by a flue 2 inches in diameter, with a vaulted chamber, alſo of brick, from the oppoſite extremity of which there paſſes out a flue of the ſame diameter as that already mentioned, terminating in a horizontal gallery, at the end of which is the chimney. The furnace is charged with the balls above mentioned, to which is added a ſomewhat variable proportion of dry bones; and with theſe materials an inceſſant fire is kept up for from four to ſix months. At the expiration of this time, the vaulted chamber and gallery are opened and the ſoot with which they are lined is ſcraped off from the top the ſides and floor, obſerving to keep the ſoot from the latter diſtinct from the reſt.

The principal new combinations that take place in conſequence of the combuſtion appear to be the following: firſt, the *pit-coal* is reſolved into gas of various kinds, into empyreumatic oil loaded with finely divided charcoal, and into carbonated ammonia: the *ſoot* forms carbonic acid, and alſo gives out the carbonated ammonia which it contained: the *bones* afford empyreumatic animal oil and carbonated ammonia; and the *common ſalt* by the action of the clay is decompoſed, its alkaline baſe remaining united to the earth, and its acid paſſing in a gaſſeous ſtate into the chamber, where it meets with and decompoſes the carbonated ammonia, forming ſal ammoniac. Hence the contents of the ſoot collected in the chamber are carbonaceous matter, muriat of ammonia, and empyreumatic bituminous oil; the latter of which is particularly abundant in the ſoot that concretes on the floor.

To ſeparate the ſal ammoniac from the other ingredients ſublimation is had recourſe to, and is thus performed. Several egg-ſhaped jars, made of earthenware, about 20 inches high and 16 in diameter, with a mouth $2\frac{1}{2}$ inches wide, are fixed in a furnace, and as ſoon as they are become moderately warm are charged with ſoot, broken into ſmall pieces, to within three inches of their mouths; a duly regulated heat is then kept up for 48 hours, in which time the volatile oil firſt riſes and paſſes out into the air, then the ſal ammoniac ſublimes and fixes itſelf to the upper part of the jars, while the earthy and carbonaceous impurities remain at the bottom: the veſſels are then broken and the cakes of ſalt extracted. Fifteen pounds of ſoot afford on an average about 5lbs of muriated ammonia. The ſoot from the floor of the chamber is too much loaded with bitumen to admit of the ſalt being extracted from it by ſimple ſublimation, and the moſt economical way of treating it is to burn it over again, by which the bitumen is deſtroyed, and the ſal ammoniac mixed with the ſoot, riſes uninjured into the chamber.

The method of carrying on the manufacture of this ſalt in England, though more complicated than the above, is, we apprehend, conſiderably more economical. The following[d] was the actual practice at a large eſtabliſhment near London, which was abandoned a few years ago in conſequence of Glauber's ſalt being ſubjected to the exciſe.

The material from which the ammonia was extracted was bones. Theſe were collected in the ſtreets and from dunghills, chiefly by old women. The bones having been thus procured, were chopped into ſmall pieces either by hatchets or machinery, and then boiled, in order to extract the greaſe or fat and marrow remaining in them, which was ſold to the ſoap-boilers. The bones were then thrown into a cylindrical iron ſtill, about 3 feet in diameter, and 8 or 9 feet long, laid horizontally over a fire-place, ſo as to be capable of being made moderately red-hot. At one end of the cylinder was a mouth about 14 inches in diameter, by which the bones were introduced, and furniſhed with a cover capable of cloſing it accurately by the help of a little lute. From the other end of the cylinder proceeded a caſt iron pipe, from 6 to 8 inches in diameter, and 18 or 20 feet long, terminating in one or more oblong leaden receivers, which were kept cool by water, placed in a veſſel of the ſame materials, the bottom of which formed their cover, the juncture being ſecured by lute. Of theſe receivers there were commonly two to each ſtill, or three to two ſtills. Every receiver was about 12 feet long, 1 foot deep, and 14 inches wide, and the refrigeratory which covered it held about 4 inches in depth of water: at the end the moſt remote from the ſtill was a pipe, fitted with a wooden plug for the purpoſe of drawing off the condenſed liquor, and above this was a hole through which the gas and incondenſible vapour paſſed off into the open air.

A ſingle charge of each ſtill yielded about 36lbs. of impure alkaline liquor, and about 30lbs. of black fetid oil floating upon its ſurface. This latter being ſkimmed off, the alkali was

[d] Original Communication.

ſaturated with ſulphuric acid, either by the addition of the mother liquor from the green vitriol makers (conſiſting for the moſt part of red ſulphat of iron); or ſtill more economically by means of calcined and pulverized gypſum: in this latter caſe after mixing the materials and ſtirring them well together, they are to be left at reſt for ſome hours, during which a double decompoſition takes place, the ſulphat of lime yielding part of its acid to the ammonia, and at the ſame time depriving this latter of its carbonic acid. The ſolution of ſulphat of ammonia thus produced is then mixed with common ſalt, by which another decompoſition takes place, the alkali of the former and the acid of the latter uniting to form muriat of ammonia, while the two remaining ingredients produce by their combination ſulphat of ſoda.

The liquor containing theſe two ſalts is then clarified by ſubſidence and decantation, and transferred into oblong leaden boilers, about 9 feet long, 3 wide, and 9 inches deep. The boilers are ſet for about ⅔ of their length on iron plates, heated by a fire beneath, the remaining part being ſupported by flat tiles defended by ſolid brick-work from the acceſs of the heat. As the water evaporates the Glauber ſalt begins to cryſtallize, and is ſwept from time to time to the cool extremity of the boiler, whence it is ſhovelled out into baſkets arranged over the end of the boiler, that the liquor which drains from the ſmall granular cryſtals may not be loſt. The evaporation is continued for ſeveral hours, till as much as poſſible of the Glauber's ſalt has been ſeparated, and the muriat of ammonia begins to cryſtallize on the ſurface of the liquor in the form of feathered ſtars. The remaining fluid is then run off into coolers, and depoſits little elſe than muriat of ammonia, till it gets below the temperature of 70° Fahr. at which time the cryſtals are to be removed, leſt they ſhould be mixed with Glauber's ſalt, which now begins to be again depoſited. After the muriat of ammonia has been ſuffered to drain in the baſkets, it is removed to a kind of oven, or even an open tiled hearth heated from below, where the water of cryſtallization is driven off, by which the ſalt becomes ſpungy, friable, and of an aſh or ſlate colour, interſperſed with ſmall white filaments.

The ſalt is now removed while hot into globular glaſs receivers, or more commonly glazed earthen jars, fitted with a cover (having a hole of above half an inch diameter in its centre) luted on with a mixture of clay and horſe-dung. Theſe are ſet in iron pots over a ſtrong fire, in a furnace of either a circular or oval form, and capable of containing from ſix to eighteen, ſurrounded with ſand up to the edge of the pot, and alſo having about two and a half inches of ſand on the cover, confined by an iron ring about three inches deep, and two inches leſs in diameter than the cover, in order that if the luting ſhould give way in any part, it may be repaired without ſuffering the covers (which ſhould be kept during the ſublimation at about 320°) to be cooled by the removal of a large portion of the ſand. Theſe earthen pans may be filled to within two inches of the top, with the dried ſalt gently preſſed in, but not rammed cloſe; and the fire, which has been lighted ſome time before, is now to be raiſed gradually till the iron pots are of a pretty ſtrong red heat all round, being ſo placed in the furnace that the upper part may be firſt heated, the bottom reſting on ſolid brick-work. During the firſt impreſſion of the heat a portion of the ſalt carrying with it a quantity of watery vapour not ſeparated on the drying place, will eſcape through the hole in the cover, which muſt be left open till all the aqueous particles are exhaled: this is known by bringing a piece of cold ſmooth iron plate near the hole in order to condenſe the ſublimate, which, becoming more and more dry, at length attaches itſelf firmly to the plate, in the form of a dry ſemi-tranſparent cruſt. At this time the hole is to be ſtopped with a bit of lute, more ſand is to be put on the cover, and the heat continued till it is judged that nearly the whole of the muriat of ammonia is ſublimed. The time requiſite for this purpoſe depends on the ſtructure of the furnace, the ſize of the pots, the briſkneſs of the fire, and other circumſtances only to be learnt by experience. The proceſs ſhould be ſtopped before the ſublimation has entirely ceaſed, as the heat in ſome parts of the jar may be too great when it is nearly empty, and either by burning a part of the ſalt itſelf, or elevating a portion of foreign matter from which it can never be kept wholly free, give the cake a yellow tinge, and a ſcorched, opake, crackled appearance. The ſame defects are likely to happen, when any part of the luting having given way, is obliged to be repaired by wet lute, when the ſublimation is pretty far advanced: conſequently glaſs veſſels are preferable, except on account of the expence, as they muſt always be broken to pieces in order to get out the cake: the jars on the contrary will ſerve for ſeveral ſublimations, even the covers, if well glazed, will laſt two operations. The ſublimation being finiſhed and the apparatus having become ſufficiently cool, the tops of the jars are to be taken off, and the cakes of ſal-ammoniac that are found adhering to them are to be ſeparated, and placed for a day or two in a damp atmoſphere, which ſoftens their ſurface a little, and thus facilitates the removal of any ſuperficial impurities. Laſtly, the cakes are packed up in caſks for ſale.

The following is a table of the proportions of dry carbonat of ammonia afforded by different ſubſtances:

Horn	$\frac{1}{5}$
Feathers	$\frac{2}{11}$
Wool	$\frac{1}{8}$
Soot	$\frac{1}{15}$
Bones	$\frac{1}{16}$
Blood	$\frac{1}{17}$
Putrid urine	$\frac{1}{46}$

In common manufactories the dry carbonat yields rather leſs than $\frac{2}{3}$ of ſal-ammoniac. In moſt of the Scotch manufactories ſoot is uſed inſtead of bones, theſe latter being only to be procured abundantly in the vicinity of a very large town.

Muriat of ammonia prepared by any of the above methods, poſſeſſes the following properties. It has no ſmell. To the taſte it is bitter, pungent, and urinous, and at the ſame time cooling: its colour, when perfectly pure, is a bluiſh-white: its texture when ſublimed is fibrous: it is tough, moderately elaſtic, and ſomewhat ductile, and hence is not very eaſily reducible to powder. Its primitive cryſtalline form is the regular octohedron, but when cryſtallized from its ſolution in water it is either in long tetrahedral pyramids or in flaky feathered cryſtals: when ſublimed it ſometimes forms rhomboids, approaching very nearly to the cube: the former cryſtals are ſomewhat deliqueſcent, but the latter, as well as every other ſublimed variety of this ſalt, are permanent in the air. Sp. gr. 1.42.

It is ſoluble in about thrice its weight of water at the ordinary temperature, and produces much cold during the ſolution: boiling water takes up its own weight of this ſalt, part of which as the ſolution cools is depoſited in beautiful feathery cryſtals.

When expoſed to a dry heat ſomewhat exceeding that at which lead melts, it begins to riſe in the form of a white vapour (without previouſly entering into fuſion) which has a peculiar odour, and attaches itſelf to cool ſurfaces. It is generally repreſented as undergoing no change by this proceſs, but according to Beaumé, after repeated ſublimations it begins to be decompoſed, a little ammonia being firſt diſcharged, and afterwards ſome muriatic acid gas.

Muriat of ammonia is decompoſable with abſtraction of its acid by the cauſtic fixed alkalies and by all the alkaline earths, more eſpecially if a moderate heat is applied: the ammonia is volatilized in the form of gas, and the acid remains behind in combination with the added alkali. If a carbonated inſtead of a pure alkali is employed, and ſublimation is had recourſe to, the ammonia riſes in a mild or carbonated ſtate.

Many of the metals and metallic oxyds are alſo capable of decompoſing muriat of ammonia in the dry way, ammoniacal gas being diſengaged, and the metal remaining behind in the ſtate of muriat. It is a remarkable circumſtance that many metals when thus treated are converted into muriated oxyds, although liquid muriatic acid has no effect upon them, thus mercury when triturated accurately with ſal-ammoniac and heated, diſengages ammoniacal gas, and muriated mercury is the reſult, if however an exceſs of ammoniacal muriat is preſent, this exceſs combines with the muriat of mercury, forming the ſal-alembroth, as we have mentioned under the article MERCURY. Silver by a ſimilar treatment decompoſes ſal ammoniac, and is itſelf converted into luna cornea.

Sulphuric acid is capable of decompoſing muriat of ammonia by diſtillation, the muriatic acid being volatilized and ſulphat of ammonia remaining in the retort. Nitric acid and muriat of ammonia re-act upon each other; the muriatic acid being liberated from its baſe by part of the nitric acid, while another portion of the ſame is decompoſed, and its oxygen paſſes to the muriatic acid, thus converting it into the oxymuriatic: hence the old chemiſts were in the habit of compoſing an aqua regia, by diſſolving ſal ammoniac in nitrous acid, for diſſolving gold; the occaſional bad conſequences of which we have mentioned when treating of that metal.

The action of nitre and ſal ammoniac in ſolution has not been inveſtigated; but if the latter ſalt is added to nitre in fuſion a partial deflagration takes place, no doubt in conſequence of the mutual decompoſition of the ammonia and nitric acid.

According to Gellert a boiling hot ſolution of muriated ammonia is capable of diſſolving vegetable reſin.

The action of ſulphur and ſal ammoniac on each other has been ſcarcely examined into. Pott affirms, that if one part of the former and two of the latter are ſublimed together, the inflammability of the ſulphur is deſtroyed.

The water of compoſition contained in ſal ammoniac is the ſame in quantity according to Beaumé, whether the ſalt is ſublimed, or cryſtallized from its aqueous ſolution. With this Mr. Kirwan agrees, who ſtates the component parts of ſal ammoniac, whether ſublimed or cryſtallized, at

42.75	Muriatic acid
25.	Ammonia
32.25	Water
100.00	

The uſes of ſal ammoniac are conſiderable. Beſide being employed in the laboratory as the ſubſtance from which pure and carbonated ammonia are procured, it is uſed in ſubſtance by the dyer, the refiner of gold, the copper-ſmith, and the manufacturer of tin-plate.

SAL AMMONIAC, NATIVE. Naturlicher Salmiak. *Wern.*

Its colour is greeniſh-white, paſſing to apple-green, or browniſh-black. It occurs in thin ſuperficial effloreſcences, or maſſive, or ſtalactical, or rarely in minute imperfect cryſtals. It has in general a ſlight vitreous luſtre. Its fracture is fine-grained uneven. It is ſoft, often friable. It has a pungent bitter ſaline taſte. In chemical characters it agrees with the manufactured ſalt.

It is found ſublimed in the crevices of volcanoes; ſuch as Etna, Veſuvius, the Solfatara, and the Lipari iſlands.

SAL DIURETICUS. See ACETITE OF POTASH.

SAL GEM. See MURIAT OF SODA *Native.*

SAL MARTIS, is the green *Sulphat* of IRON.

SAL POLYCHREST, is SULPHAT of *Potaſh* calcined with a very ſmall portion of ſulphur, formerly uſed in medicine.

SAL PRUNELLA, is NITRAT of *Potaſh*, from which the water of cryſtallization has been expelled by fuſion.

SALIVA. This fluid, analyzed by Vauquelin, was found to conſiſt of water holding in ſolution a ſmall quantity of mucus and muriat of ſoda.

SALT. This term has been ſo variouſly applied that it is ſcarcely poſſible to give an accurate definition of it. The general and the moſt antient idea of a ſalt is, a cryſtallizable ſubſtance, conſiderably ſoluble in water, and highly ſapid, but the term is at preſent applied to all the cryſtallizable acids or alkalies, or earths, or combinations of acids with alkalies, earths, or metallic oxyds. Hence the common and uſeful diſtinction of the compounded ſalts into *alkaline*, *earthy*, and *metallic.* In ſo doing however, and by including all the cryſtallizable combinations of acids and baſes, ſome compounds have got the name of ſalts which want the primary, and what would formerly have been conſidered as eſſential, qualities of ſolubility and ſapidity, of which ſulphat of barytes is an example, which is abſolutely inſoluble in water and taſteleſs. It is ſtill however cryſtallizable or found cryſtallized, which appears to be an invariable character of a ſalt. Thus this appellation was long denied to carbonat of magneſia, till the diſcovery of the cryſtallizable ſoluble carbonat of this earth.

There are many triple combinations alſo of theſe ingredients which belong to the claſs of ſalts, ſuch as alum, tartarized antimony, &c.

Salts are alſo either *neutral* (that is where the ingredients are in exact ſaturation) or with the acid in exceſs, of which tartar is an example, or with an exceſs of the baſe, as in borax. Theſe circumſtances have been ingeniouſly diſtinguiſhed in nomenclature by Dr. Thomſon, by the prefix *ſuper* in the firſt caſe, and *ſub* in the latter. Thus tartar is named with propriety the *ſuper-tartrite of potaſh;* borax, the *ſub-borat of ſoda*, &c.

The chemiſtry of ſalts, taken in the moſt extended ſenſe, forms by far the largeſt part of the whole ſcience.

The term *Salt* is alſo uſed emphatically for common ſalt, or muriat of ſoda.

SALT *Bitter*, *Purging*, or *Epſom.* See SULPHAT *of Magneſia.*

SALT *Glauber's.* See SULPHAT *of Soda.*

SALT *of Hartſhorn.* See CARBONAT of *Ammonia.*

SALT *Sedative.* See BORACIC *Acid.*

SALT of *Seignette* or *Rochelle.* See TARTRITE of *Soda* and *Potaſh.*

SALT of *Silvius.* See ACETITE of *Potaſh.*

SALT of *Sorrel.* See OXALAT of *Potaſh.*

SALT, *Spirit of.* See MURIATIC *Acid.*

SALT of *Tartar* } See CARBONAT of
SALT of *Wormwood* } *Potaſh.*

SALTPETRE. See NITRAT of *Potaſh.*

SANDARACH. See ARSENIC, *Sulphuret of.*

SAND-BATH. See the Appendix on Chemical Apparatus.

SANDIVER, is the ſcum and ſediment of the large crucibles uſed in the making of Glass, which ſee.

SAND. *Sand*, Germ. *Sable*, Fr.

SANDSTONE. *Sandſtein*, Germ. *Gres*. Fr.

The eſſential component part of ſandſtone is quartz in rounded grains of various ſizes, from the ſmalleſt that are viſible to the naked eye to thoſe that are about the magnitude of a muſtard ſeed. All ſandſtones are ſtratified, but in ſome beds there alſo occur pretty regular fiſſures in two directions perpendicular to the ſtratification, thus dividing the ſtone into parallelopipedal maſſes. When diſintegrated it forms Sand.

There are ſeveral diſtinct formations of ſandſtone, but mineralogiſts are by no means as yet agreed with reſpect to their number; the four following, however, are made out with tolerable accuracy.

1. Primitive calcareous ſandſtone.

Its colour is for the moſt part greyiſh or greeniſh grey. It occurs in maſs. Its fracture is ſplintery; its fragments are blunt-edged; it is tranſlucent at the edges, is moderately hard, giving a few ſparks when ſtruck againſt the ſteel. It efferveſces with acids, and when its calcareous cement is diſſolved out, there remains a very friable maſs of fine white ſand. It does not appear to contain any extraneous minerals. It reſts upon gneiſs and large-grained granite.

2. Ferruginous ſandſtone.

The colour of this is for the moſt part ochery red or reddiſh brown, ſometimes though rarely it is yellowiſh white. Its fracture is very coarſe ſplintery; it is opake and ſoft, being reduced to ſand by a moderate blow. It ſeldom efferveſces with acids, its cement being almoſt always iron ochre with a little clay. It readily diſintegrates by expoſure to the weather. It contains not unfrequently extraneous minerals, ſuch as reddle in ſmall fragments, vitreous copper and other ores of this metal, and very rarely galena, alſo petrified wood. In Thuringia it is covered with bituminous marlite.

3. Gritſtone.

Of this there are two varieties, the compact and ſchiſtoſe.

The former is of a greyiſh white colour, ſometimes ſpotted or ſtriped with ochre yellow. Its fracture is coarſe ſplintery. It very rarely efferveſces with acids. It is harder than the preceding and gives lively ſparks when ſtruck againſt the ſteel. It is not readily decompoſed by expoſure to the air.

The ſchiſtoſe grit differs from the preceding in its fracture which is coarſe ſlaty, and in being more eaſily pulverizable. It is ſometimes intimately mixed with clay and then forms the common *flag-ſtone*, in which ſtate its croſs fracture is earthy, and it contains impreſſions of ſhells.

Gritſtone generally occurs in the independent coal-formation, and contains few extraneous minerals except mica which is particularly abundant in the ſchiſtoſe variety. The elaſtic quartz or flexible ſandſtone of South America, appears only to be a kind of ſchiſtoſe grit.

4. Soft calcareous ſandſtone. Molaſſe, *Fr.*

The uſual colour of this is light greyiſh or yellowiſh. Its fracture is coarſe ſplintery, paſſing into granular. It is ſoft, and when in the quarry is almoſt friable, but hardens by expoſure to the air. Its cement is calcareous.

It occurs alternating with oolite and the other moſt recent varieties of limeſtone.

The uſes of ſandſtone are very conſiderable. It is the ſtone moſt commonly employed in architecture; the ſchiſtoſe varieties are uſed as flag-ſtones, and for covering houſes, for which laſt purpoſe however they are inferior to ſlate; the harder kinds of gritſtone are made into grindſtones, and on account of their infuſibility are employed for lining furnaces, &c.

SAP. The ſap of trees is a watery mucilaginous liquid, often ſtrongly ſaccharine, ſo as even to yield a large quantity of ſugar, and to furniſh a very ſtrong fermented liquor, and containing ſeveral other ſaline ſubſtances. It appears to vary conſiderably in its compoſition, and to fall very far ſhort of the uniformity which diſtinguiſhes the common juice of animals.

The mode of extracting *Sugar* from the ſap of the maple, will be mentioned under that article.

Vauquelin has made an uſeful though incompleat analyſis of the ſap of ſeveral of the common trees, chiefly with a view to the ſaline and earthy contents, and has diſcovered the preſence of acetite of potaſh in all of them, which entitles the acetous acid to be ranked among the native acids as well as being a product of fermentation.

The following is a ſhort abſtract of Vauquelin's experiments.[a]

Sap of the Elm. This juice, which was collected in the ſpring, has a yellowiſh red colour and mild and mucilaginous taſte, and ſhews no exceſs of acid.

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[a] An. Chim. tom. xxxi.

Ammonia produces an abundant yellowiſh precipitate, reſoluble in acids with efferveſcence, and which conſiſts chiefly of carbonated lime with a little vegetable matter. Barytic and lime-water produce the ſame. Oxalic acid and nitrat of ſilver give a white precipitate, ſulphuric acid excites a ſtrong efferveſcence, and the gas has a powerful ſmell of acetous acid. Oxymuriatic acid gives a yellow precipitate, and alcohol a flocculent one. This liquor was analyſed in the following way; 1039 grammes were heated in an open veſſel and during the evaporation a brown earthy matter gradually fell down and fixed to the ſides of the veſſel. When nine-tenths of the liquid were waſted by ſlow evaporation the reſidue was cooled, and the brown earth was ſeparately treated with muriatic acid which diſſolved a portion with efferveſcence, and left an inſoluble portion, which when waſhed and dried amounted to 637 grammes. The muriatic ſolution, decompoſed by carbonated potaſh gave 0.5 grammes of carbonat of lime. The evaporated liquid freed from the earthy depoſit, ſtill contained much flocculent matter which was ſeparated by filtration and weighed when dry 43 grammes, part of which diſſolved in muriatic acid, and produced by precipitation .318 grammes of carbonat of lime, and .425 of inſoluble vegetable matter remained. The concentrated and filtered liquor was finally evaporated to dryneſs and gave 9.553 grammes of a grey extract, ſtrongly deliqueſcent, and with a pungent ſaline taſte. Sulphuric acid added to it gave a ſtrong ſmell of radical vinegar, and a notable quantity of this latter acid was procured by diſtilling the extract with ſulphuric acid.

The author eſtimates the above 1039 grammes of ſap to contain .795 grammes of carbonat of lime; 1.06 of vegetable matter; and 9.24 of acetite of potaſh. The latter however is probably given by eſtimation from the quantity of acetous acid obtained by diſtillation, and is therefore liable to much uncertainty, and if the particulars of the analyſis are correctly given, the carbonat of lime ought to be .818 (.318+.5) inſtead of .795. The accuracy of theſe numbers however is of leſs importance, as there is no doubt that the varieties of ſoil, ſeaſon, climate, &c. influence much the compoſition of the ſap.

Sap of the Aſh. This juice had a reddiſh brown colour, and an aſtringent taſte like the infuſion of tan. With reagents it was ſimilar to the laſt, except that ſulphat of iron was blackened with this ſap, and animal jelly gave a precipitate. It contained a little acid in exceſs, a calcareous ſalt, gallic acid and tan, beſides a vegetable extract, and a ſlight trace of ammonia. The extract left after evaporation to dryneſs and calcination was found to contain a little alumine.

Sap of Hornbeam. This juice is colourleſs and limpid in its natural ſtate, has a ſoft and decidedly ſaccharine taſte, a ſmell reſembling whey, and a conſiderable exceſs of acid. When expoſed to the air undiſturbed for a length of time, it firſt becomes milky, and throws up a ſlight down on its ſurface, then it parts with much carbonic acid, afterwards it acquires a vinous ſmell and taſte, and at the ſame time its acidity increaſes, and it becomes limpid from the ſubſidence of ſome kind of mucilage. In about five or ſix weeks, in the ſummer time, this ſpontaneous acidity is at its higheſt, after which it ſenſibly diminiſhes, a thick white mucilaginous mould forms on the ſurface, all taſte of an acid is gone, and the liquor only taſtes mouldy. The ſame ſubſtance, kept in a cloſed bottle, remains apparently but little altered, except that there is ſo great a generation of acetous acid that the liquor would make by itſelf a good ſubſtitute for vinegar in the ſeaſoning of food.

Sap of Birch. This is a colourleſs ſaccharine acid liquor which is fermentable in its natural ſtate, and its extract left after evaporation is equally ſo. The author attempted but without ſucceſs, to extract ſugar from it by the uſual means.

Though this excellent chemiſt has not mentioned it in this place, it is probable that theſe ſaps alſo contain a quantity of *malat of lime*, the extraction of which is deſcribed under that article.

SAPPARE. See CYANITE.

SAPPHIRE. See CORUNDUM.

SARDONYX. See CHALCEDONY.

SASSOLIN. Is the native BORACIC ACID of Saſſo in Tuſcany, which ſee.

SATTIN SPAR. See LIMESTONE fibrous.

SATURATION.

A ſubſtance is ſaid to be ſaturated with another, either (in the caſe of ſimple ſolution) when the ſolvent will take up no more of the ſubſtance diſſolved, or (in the caſe of mutual chemical action) where the compound produced is perfectly neutralized.

SAUNDERS WOOD.

There are three ſpecies of wood known by this name, the *White*, the *Yellow*, and the *Red*. Of theſe the two former were never employed but in medicine, and are now entirely diſuſed. Theſe two are procured from varieties of the ſame tree, but the tree that yields the red ſaunders is a totally different ſpecies.

White and Yellow Saunders Wood. Theſe woods are brought over in large billets from ſeveral parts of the Eaſt Indies, and are ſaid to be chiefly the produce of the iſland Timor in the Indian Ocean. The white Saunders is of a pale yellowiſh white hue, and almoſt taſteleſs. It is ſeldom ſeen and requires no further notice in this place.

The yellow Saunders is of a pale yellowiſh colour, a fragrant roſe ſmell, and a bitteriſh aromatic taſte. There is ſome doubt whether it is not the ſame tree that yields both the white and yellow, according to the difference of age and ſoil. Both woods are hard and heavy.

The yellow Saunders diſtilled with water gives a fragrant eſſential oil which thickens in the cold to the conſiſtence of a balſam. The watery decoction yields a bitteriſh ſomewhat pungent extract.

Alcohol forms a fine yellow tincture, which after the ſpirit has been evaporated leaves a ſemi-fluid fragrant reſin.

This wood is ſcarcely ever uſed in Europe, but is much valued in the Eaſt for its fragrant ſcent.

Red Saunders Wood. This wood (yielded by the pterocarpus ſantalinus) is alſo brought from the Eaſt Indies, and comes over in round billets of a blackiſh red on the outſide, but of a deep brighter red within and a wavy grain. Though when recent it appears to be highly fragrant, it is nearly without ſmell or taſte in the ſtate in which we receive it, and is ſolely valuable for the deep red it gives out to alcohol. Water digeſted with it has no effect on the red tinge, and only becomes of a pale yellow, but alcohol readily acquires a fine bright full-bodied red. This tincture yields a dark red extract amounting to near a fourth of the weight of the wood. The fixed oils are not coloured by red Saunders, but a few of the volatile oils receive a red tinge. This wood is often confounded with Brazil wood, as they much reſemble each other in appearance. They are however readily diſtinguiſhed by this circumſtance, that Brazil wood gives out its red colour to water as well as alcohol, but Saunders wood only to alcohol.

This latter circumſtance renders this wood of no uſe in general dyeing, but it is occaſionally uſed for colouring ſpirits, as, for example, the red ſpirit uſed for thermometers.

SEA-WATER.

The compoſition of ſea-water and the mode of extracting the ſalt from it are deſcribed under the article MURIAT *of Soda*. See alſo SULPHAT *of Magneſia*; and WATERS, *Mineral*.

SEBACIC ACID, or *Acid of Fat*. *Fettſaure*. Germ.

When any kind of animal oil is ſubjected to a heat ſufficient to volatilize it, ſeveral new products are formed, and among others a very pungent acid liquor may be collected by condenſation, which has been particularly examined by ſeveral chemiſts, and having been conſidered as a peculiar acid it has been termed the *Acid of Fat* or *Sebacic Acid*. A ſimilar acid may alſo be procured from fat without diſtillation of the entire fat, in the way that will be preſently mentioned, whence this acid has been ſuppoſed to exiſt naturally in fat in intimate union with the oily part. The properties of this acid, and the products of the diſtillation of animal oil have been particularly noticed by Crell in two very elaborate memoirs, publiſhed in the Philoſophical Tranſactions,[a] of which we ſhall give a very ſhort extract.

Since this period however another acid ſubſtance differing from the former in many eſſential particulars (eſpecially in being free from ſmell) has been diſcovered by Thenard,[b] which he conſiders as the true ſebacic acid, and the pungent acid of Crell and other chemiſts, he aſſerts to be chiefly a modification of the acetous acid. But as ſeveral objections might be raiſed againſt this opinion, we ſhall give the experiments of each chemiſt.

Thoſe of Crell are in a few words, the following:

A quantity of beef ſuet was firſt melted and ſtrained to ſeparate all the impurities: 2 lbs. of this were put into a glaſs retort ſet in a reverberatory ſand-bath, and a receiver was cloſely luted on. Heat was applied, by which the ſuet firſt melted then diſtilled quietly with a gentle frothing. There firſt came over into the receiver a thin limpid oil which did not congeal, after which came an acid liquor, mixed with a denſer and coloured oil, the former of which remained fluid, but the latter congealed in the receiver. This mixed product continued for ſixteen hours, at the end of which the retort was fully red-hot, and every thing volatile had diſtilled over. On opening the receiver when cold, a moſt pungent ſuffocating fetid vapour exhaled, which is characteriſtic of this proceſs, and the receiver contained three ſubſtances, namely, a congealed oil of the conſiſtence of hog's lard, and ſtrongly pungent, over which ſwam two liquors perfectly diſtinct, the upper of which was a greeniſh limpid oil, and the lower was a moſt pungent gold coloured acid liquor. The retort contained about $1\frac{1}{2}$ oz. of a ſmooth gloſſy charcoal. The congealed oil ſtill retained much of the acid liquor, which was ſeparated by melting and waſhing with hot water. This waſhed oil was ſubjected to ſeparate diſtillation, by which it was again reſolved into a congealable oil, and an acid liquor, and the ſame proceſs was repeated ſucceſſively with each product of congealed oil after waſhing, till all the acid liquor which it would yield was got out. By a ſucceſſion of diſtillations of the congealed reſidue, the quantity of it gradually diminiſhed, and at laſt it finally diſappeared; ſo that the whole 2 lbs. of ſuet was reſolved into various liquid products, and a carbonaceous reſidue. The former were all mixed together, and then ſpontaneouſly ſeparated into two liquors, one a golden coloured acid, weighing 3 oz. 5 drams, the other a yellowiſh brown oil, weighing $21\frac{1}{2}$ oz. The charcoal weighed 5 oz. 2 ſcruples, which weights added together left a deficiency from the original quantity of ſuet, amounting to 1 oz. 6 drs. 1 ſcr.

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[a] Vol. 70 and 72.

[b] An. Chim. tom. 29.

We ſhall not follow this laborious chemiſt in his experiments on the oil and the charcoal, except to mention that the former after waſhing to ſeparate the adhering acid, yielded by diſtillation in a very gentle heat with water, a limpid oil reſembling that of *Dippel*, already mentioned under the article *Bone*.

The acid liquor which was brown, was then diſtilled *per ſe* in a gentle heat, by which a yellowiſh white and rectified acid liquor was obtained, and a carbonaceous greaſy maſs remained in the retort. This rectified liquor was then combined with the ſeveral alkaline, earthy, and metallic baſes, with many of which it united very readily, effervеſcing ſtrongly with their carbonats and producing neutral ſalts, ſome of which will be preſently deſcribed.

The ſame ingenious chemiſt ſucceeded in concentrating this acid by ſaturating the acid liquor with potaſh, evaporating and thoroughly drying the ſalt, and then decompoſing it by the ſulphuric acid and diſtillation, by which a ſtrong limpid acid was obtained.

But as this method was attended with much trouble and waſte, the following mode was employed as an improvement in the proceſs: a ley of cauſtic potaſh was made with a pound of ſalt of tartar, and half a pound of quicklime, which was diſſolved in 6 lbs. of water. A fourth part of this was boiled with a pound of ſuet, and the whole evaporated till it began to ſtiffen conſiderably. The remaining three fourths of the ley were then added, and the whole was boiled with a ſlow fire and conſtant ſtirring, till the mixture became pellucid, and when cold concreted into a kind of gelatinous ſoap. This was then diſſolved in water and ſome powdered alum was added, which immediately produced a decompoſition, the oil of the ſoap uniting ſolely with the alumine into an inſoluble curdy maſs. The addition of alum was continued till the formation of this curdy maſs had ceaſed, and the liquor ſeparated from it now contained ſulphat of potaſh, and another neutral ſalt of potaſh, and the acid of fat. This was evaporated to dryneſs and then put into a retort, to which was added a third of its weight of oil of vitriol, which immediately extricated grey vapours ſtrongly impregnated with the peculiar ſmell of the acid of fat. By applying a very moderate heat, all the acid of fat was expelled, unmixed with ſulphuric acid, and it condenſed into a fuming, limpid, ſtrong acid of fat, which when added to a ſolution of acetited lead produced a precipitate which was again ſoluble in an exceſs of acetous acid, and therefore contained no ſulphuric acid.

When this limpid acid of fat was diſtilled in a retort till half the quantity had come over clear and colourleſs, the reſidue now acquired a golden colour, and depoſited brown ſtreaks. The limpid acid in the receiver, again diſtilled *per ſe*, again reſolved itſelf into another limpid fluid which paſſed over into the receiver, and the reſidue as before depoſited theſe brown ſtreaks. This was repeated eight times, always ſelecting the clear liquid which had been diſtilled over in the previous operation, and to the laſt, a quantity of brown inſoluble matter was left behind, whilſt the diſtilled acid gradually loſt its pungency, and ſomewhat of its acidity, by theſe ſucceſſive proceſſes.

There are at leaſt three ways of obtaining this volatile acid of fat; one is by mere diſtillation of any animal fat, ſeparation of the acid liquor from the other products, and rectification in the way already mentioned, and in this way no intermede whatever is employed. Another way is by decompoſing an animal alkaline ſoap by alum, and diſtilling the clear remaining reſidue with ſulphuric acid; and a third, which indeed ſomewhat reſembles the laſt, and was employed by De Segner, previous to Crell's experiments, is to ſaturate the diſtilled acid liquor with potaſh, and then to decompoſe it by diſtillation with half as much ſulphuric acid as there was carbonat of potaſh employed.

The ſame acid may alſo be prepared according to Guyton, in the following way: mix any kind of animal fat with ſome powdered quicklime, melt the mixture in an iron pot for a time, and when cold, lixiviate the reſidue with warm water, which diſſolves out the ſebat of lime. Evaporate this liquor to dryneſs, by which a brown ſalt is left, which calcine in a crucible, then lixiviate and filter the ſolution, and evaporate to dryneſs. Laſtly, decompoſe this calcareous ſalt by ſulphuric acid, and the limpid pungent acid of fat will riſe.

Before we proceed to deſcribe the *Sebats*, we ſhall mention that peculiar acid diſcovered by Thenard, which alone he conſiders as pure ſebacic acid. His proceſs was the following: A large quantity of pork lard was diſtilled *per ſe*; the product was waſhed with much warm water and all the watery liquids were united. Acetited lead was then poured in, and a flocculent precipitate fell down, which was collected and dried, and conſiſted of *ſebat of lead*. This was then put into a retort with ſulphuric acid and diſtilled. The liquor in the recipient *had no acid property*, but on the ſurface of the liquor remaining in the retort there floated a melted maſs reſembling fat in appearance, which was carefully collected, and after waſhing was boiled with water. At this heat it diſſolved, and on cooling it depoſited tender needled cryſtals, which were decidedly acid, and which the author conſiders as the pure *ſebacic acid*. To aſcertain whether they were or were not *produced* by the ſulphuric acid, ſome of the ſimply diſtilled liquor of lard was treated with water, filtered and evaporated, and ſome of the ſame cryſtals were ſeparated on cooling, ſhewing therefore that this ſubſtance either exiſted in that ſtate in the freſh lard, or was produced by the mere action of fire, and not by the ſulphuric acid.

This ſebacic acid is without ſmell, has a ſlightly acid taſte, reddens litmus, melts in heat like greaſe, and is much more ſoluble in hot water than in cold, ſo that a hot ſolution at all concentrated, readily concretes by cooling. It is alſo ſoluble largely in alcohol, and cryſtallizes in ſmall needles, but by careful management it may be obtained in the form of broad brilliant plates.

Thenard alſo aſſerts that along with the ſebacic acid much acetous acid is contained in the diſtilled liquor of lard, and that it is this, and not the true ſebacic acid which is given out, when according to Segner's method the liquor is ſaturated with potaſh, evaporated to dryneſs, and decompoſed by ſulphuric acid. In proof of which he aſſerts that in performing the experiment, he obtained under theſe circumſtances, an acid, which, like the acetous, produces a deliqueſcent foliated ſalt with potaſh that has a very pungent taſte, that forms with nitrat of mercury a precipitate which cryſtallizes in plates, and that gives much acetous acid when treated with ſulphuric acid. With regard to the acid obtained by Crell's ſecond proceſs, that is, by treating the fat with alkali and alum, and decompoſing by ſulphuric acid, Thenard aſſerts that on repeating this proceſs he obtained no acetous acid, but only *muriatic*, ſince it precipitates nitrat of ſilver, and forms a cubic ſalt with ſoda, which ſalt, decompoſed ſeparately by ſulphuric acid, gives a penetrating acid vapour, which united with the nitric acid is capable of diſſolving gold. This acid he attributes to employing the common potaſh of commerce, which always contains ſome muriat, for in repeating the experiment with pure potaſh, he obtained no acid except a minute quantity of vinegar.

Such are the experiments of this chemiſt, who is certainly worthy of the higheſt confidence, and they eſtabliſh the fact of there exiſting an inodorous, not eaſily volatile, and cryſtallizable acid ſubſtance in the products of diſtilled fat, to which the term *Sebacic acid* ought probably to be applied.

This acid precipitates the acetite and nitrat of lead, nitrat of ſilver, and acetite and nitrat of mercury; it ſaturates the alkaline baſes, and forms with them ſoluble ſalts; with potaſh it forms a ſalt which does not abſorb moiſture from the air, and is decompoſed by the mineral acids; it does not trouble barytic, lime, or ſtrontian water.

We cannot however admit the explanation given by this ingenious chemiſt of the nature of Crell's volatile acid, to the full extent, without further experiments, though it is ſufficiently probable that it is a very compound liquor, containing a large quantity of acetous acid, perhaps with ſome ſulphureous, and intimately combined with a portion of animal oil.

Every acid procured in any manner from animal fat is probably *formed* by the diſtillation or by the action of the ſulphuric acid, and not merely *evolved*, ſince no change in the colour of litmus is produced by the contact of fat, or of water employed to lixiviate it. That the action of heat or ſulphuric acid ſhould produce acetous acid from materials which abound in its conſtituent parts, may readily be conceived, and the hiſtory of the pyroligneous, lactic, and ſome other acids ſhews how readily the acetous acid undergoes particular modifications by which its proper characters are diſguiſed ſo as not eaſily to be detected.

However, till the nature of the pungent volatile acid of fat is fully cleared up, it may be right to give ſome of the general characters of its ſaline combinations,[a] though we ſhould heſitate to give them the term of *Sebats*.

When the alkalies are ſaturated with this acid, and the mixture is evaporated to dryneſs, rediſſolved and concentrated, cryſtals are formed generally in plates and not deliqueſcent. Theſe are all decompoſable by ſulphuric acid, and give out vapours, ſtrongly ſmelling of acetous acid, but with a peculiar pungency. A ſimilar ſalt is formed with lime, but with magneſia and alumine no cryſtals can be obtained.

This acid has no action on gold or ſilver, but diſſolves the oxyd of the latter metal. It acts on mercury when repeatedly abſtracted from it, but diſſolves the white carbonated oxyd with eaſe in the cold. This ſalt evaporated to dryneſs and heated, yields a mercurial ſublimate in a very moderate temperature.

Copper diſſolves in this acid with eaſe, and yields ſmall deliqueſcent cryſtals. Iron gives an aſtringent ſolution, and by evaporation leaves acicular cryſtals, ſcarcely deliqueſcent. Lead, antimony, zinc, and tin, are diſſolved with more or leſs eaſe.

With ſome of the metallic ſolutions this acid produces ſenſible effects. Added to nitrated ſilver, a reddiſh grey precipitate falls down. With nitrated mercury a white precipitate is produced, and even corroſive ſublimate is made turbid by this acid. With nitrat of lead, ſmall acicular cryſtals are depoſited which are readily ſoluble in water, and this latter ſolution is decompoſed by ſulphuric acid.

It is obvious that theſe properties do not belong ſingly either to the acetous or to the muriatic acid, ſo that till we have further experiments, we muſt for the preſent admit ſomething peculiar in the pungent diſtilled acid of fat.

SELENITE. See Gypsum.

SEMI-METAL. A name given by the old chemiſts to the brittle unmalleable metals. See Metal.

SEMIOPAL. See Opal.

SENEGAL, *Gum*. See Mucilage.

SERPENTINE. *Serpentin*, Germ. *Serpentine*, Broch.

Of this mineral there are the two following ſubſpecies.

1. *Subſp.* Common ſerpentine.

Its colour is chiefly green of different ſhades, from pale leek green to olive and blackiſh green, it alſo occurs blood red, ſcarlet red, light crimſon, and reddiſh brown, ſometimes, though rarely, browniſh yellow. The colours are arranged in dots, clouds, veins, and ſtripes, and are very much intermixed. It occurs in maſs. It is internally dull, or faintly glimmering when mixed with foreign particles. Its fracture is ſplintery paſſing into fine grained uneven, alſo flat conchoidal. Its fragments are indeterminate, blunt-edged. It is uſually tranſlucent on the edges; it is ſoft, eaſily frangible, and unctuous to the touch. Sp. gr. 2.57—2.7.

It is infuſible before the blow-pipe without addition. It appears to admit of conſiderable variety in its analyſis, as appears from its examination by Kirwan and by Bayen.

	Kirwan.		Bayen.
Silex - -	45	—	41
Magneſia -	23	—	35
Alumine -	18	—	10
Iron - -	3	—	3
Water - -	12		
	98		89

A little oxyd of chrome is alſo ſaid to have been lately found in this mineral.

2. *Subſp.* Noble ſerpentine.

Its colour is deep leek green, paſſing into greeniſh black. It occurs in maſs or diſſeminated. It has a ſlight greaſy or reſinous luſtre. Its fracture is conchoidal paſſing into ſplintery. It is tranſlucent, ſoft, unctuous to the touch.

Serpentine ranks among the primitive rocks; it very rarely contains beds of other minerals. It is not unfrequently penetrated by veins conſiſting of calcareous ſpar, granular limeſtone, ſteatite, talc, aſbeſt, garnet, copper, and magnetic iron.

There appear to be two diſtinct formations of this mineral; the moſt ancient is in ſmaller rock maſſes than the other, and reſts upon granite or gneiſs; the noble ſerpentine belongs almoſt wholly to this formation. The other formation is more recent, is leſs penetrated by veins, and conſiſts of common ſerpentine.

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[a] Crell.

The older ſerpentine is found in Corſica, Italy, and Siberia, and of uncommon beauty at Portſoy in Scotland. The more recent ſerpentine occurs in Cornwall, at Zöblitz in Saxony, and various other parts of Germany.

This mineral is capable of being readily faſhioned in a lathe, and of receiving a very good poliſh, on which account it is formed into various articles of ornament and uſe, ſuch as vaſes, chimney-pieces, &c. many of which are exquiſitely beautiful.

SERUM. See Blood.

SHELL.

The ſhells of marine animals and of all eggs have long been known to conſiſt principally of carbonat of lime, ſo that when burned they afford a purer quicklime than that procured from moſt of the common lime-ſtones, and on the ſea-coaſt ſhells are often collected in quantity, and employed for making quicklime. All ſhells therefore effervеſce ſtongly with acids.

But as they are *organized* parts of living animals they have ſome peculiarities of texture dependent on the mode of their formation, and the earthy part of which they are compoſed muſt have been held together by ſome animal cement, and not merely cohering by ſimple aggregation. Beſides this they moſtly contain ſome portion of phoſphat of lime, though in very ſmall quantity compared with the carbonat, and alſo in compariſon with the quantity entering into bone, and the hard parts of land animals.

Mr. Hatchett has given a very valuable memoir on the various ſpecies of marine ſhells, which is uſeful not only as a regiſter of chemical analyſes, but as ſhewing a diſtinction between ſeveral large claſſes of ſhell and elucidating the mode of their formation.[a]

The method of analyſis was ſo ſimple that it may be deſcribed at firſt as applying to all. The ſhell was firſt immerſed in dilute nitric or ſometimes in acetous acid, and a ſolution was effected, without heat, of all the calcareous part, which ſometimes required a digeſtion of a few days. The acid here diſſolved both the carbonat and phoſphat of lime if preſent, but would leave the cementing animal membrane, which being of the nature of condenſed albumen would remain undiſſolved. It would alſo leave untouched any animal charcoal produced by previouſly roaſting the ſhell in a red heat for a ſhort time, and charring the cementing gluten, which, when not actually in the ſtate of denſe membrane, would otherwiſe diſſolve in the acid. To the ſolution pure ammonia was firſt added as long as it produced any precipitate, which in theſe circumſtances was phoſphat of lime undecompoſed. The remaining clear liquor was then fully ſaturated with carbonat of ammonia, which precipitated all the carbonat of lime, and thus theſe two calcareous ſalts were ſeparated, and their quantity aſcertained. Sometimes however the ſubſtance when of a cellular or porous ſtructure, would contain ſome ſlime and argil, too cloſely adhering to be ſeparated properly, in which caſe the alumine diſſolved along with the calcareous ſalts would be precipitated by ammonia as well as the phoſphat, and would be blended with it. In ſuch caſes the mixed precipitate was rediſſolved in nitric acid and acetite of lead dropped in, which would ſeparate the phoſphoric acid in the form of an inſoluble phoſphat of lead, and the quantity of acid, (and from this, that of lime united to it) could be thus eaſily eſtimated.

There are two great claſſes of marine ſhells, the teſtaceous and the cruſtaceous. The former are by much the moſt numerous, and include all the marine ſhell-animals that have not legs and the power of tranſporting themſelves from place to place: the cruſtaceous ſhells are thoſe of the lobſter, crab, prawn, and ſuch animals as readily ſhift their place, and who carry the ſhell merely for protection from external injury, and not alſo, as in the teſtaceous, as a place of reſidence.

The teſtaceous ſhells again are diviſible into two claſſes, the *Porcellanous* and thoſe compoſed of *Nacre* or *Mother of Pearl*, which differ from each other in the quantity of connecting gluten or membrane, and the mode in which it is diſpoſed.

The *Porcellanous ſhells* are ſo called becauſe they have an aſpect like porcelain, with an enamelled gloſſy ſurface, are ſmooth, hard, and ſonorous, and when broken often exhibit a ſlightly fibrous texture. All the univalve ſhells, ſuch as whelks, limpets, cowries, and moſt of the beautiful convoluted ſhells of tropical countries are of this deſcription.

Theſe ſhells when expoſed to a red heat in a crucible for a quarter of an hour, crackled and loſt the colours of their enamelled ſurface, but did not emit any apparent ſmoke, nor any ſmell like burned horn or cartilage. Their figure remained unchanged and they all became of an opake white, retaining part of their original gloſs. Theſe diſſolved in acids with great effervescence, and when they had not been previouſly roaſted, the ſolution remained clear, but after roaſting, the charred gluten was left untouched. Neither ammonia nor acetited lead diſcovered any phoſphat, ſo that theſe ſhells ſeem to conſiſt entirely of carbonat of lime cemented by a ſmall portion of animal gluten.

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[a] Phil. Tranſ. vol. 89 and 90.

The *Nacreous Shells* are moſtly bivalved, and have a ſofter texture, a greater gloſs on the inner ſide, and often ſhew that irideſcent play of colours which is ſo particularly beautiful in the mother of pearl. All the oyſter and muſcle ſpecies are of this kind. When put in the fire they give a ſenſible odour of burned horn with ſome ſmoke, and exfoliate. When the roaſted ſhells were immerſed in nitric acid a much greater proportion of charcoal was left than in the former kind. But the moſt ſtriking difference was with the unburned ſhell, for when immerſed in the acid a violent effervescence and rapid ſolution took place at firſt, but diminiſhed gradually, ſo that the carbonic acid was only diſengaged at intervals. In two days time the whole of the calcareous part was diſſolved, but a reticulated ſeries of membranous layers was left, the outermoſt of which was the epidermis or ſkin of the natural ſhell, ſo that the whole formed a tender maſs of membranes ſtill retaining the form of the ſhell. Each membrane therefore has its correſponding ſtratum of calcareous earth interpoſed between it and the ſucceeding membrane, and hence as every additional ſtratum exceeds in extent that which was previouſly formed, the ſhell becomes ſtronger and thicker in proportion as the animal grows. Hence the vaſt thickneſs of ſhell in the large full-grown oyſters that yield the mother of pearl. The nitric ſolution of theſe ſhells ſhewed no indication of any phoſphat, ſo that the earth is merely carbonat of lime.

A ſecond claſs of ſhells has been ſtated to be the *Cruſtaceous*, ſuch as form the covering of the lobſter, crab, &c. Pieces of this ſhell were immerſed in nitrous and acetous acids, in each of which they diſſolved with moderate effervescence to a conſiderable degree, but in a ſhort time the action ceaſed and a yellowiſh white elaſtic cartilage was left, which retained the original form. In the acetous acid the colouring matter alſo remained and was ſoluble in alcohol. Theſe ſolutions contain both phoſphat and carbonat of lime, and thus it is the preſence of phoſphat of lime, though the quantity is comparatively ſmall, which diſtinguiſhes the cruſtaceous from all the teſtaceous ſhells whether porcellanous or of nacre.

It may be added that pearls reſemble exactly in chemical compoſition, the nacre or mother of pearl; and that egg-ſhell bears the ſtrongeſt affinity with the porcellanous ſhells.

SIDERITE.

Is a name given by Bergman to a ſuppoſed peculiar metallic ſubſtance which is the principal cauſe of the brittleneſs of certain kinds of bar iron. It has ſince been diſcovered to be phoſphat of iron.

SIENITE. *Sienit.* Wern.

This is one of the compound primitive rocks and conſiſts eſſentially of cryſtals and grains of hornblende imbedded in felſpar. When the felſpar is compact the maſs has a porphyritic character and is often called Sienitic porphyry. Quartz and mica are occaſionally found in ſienite but in very ſmall quantity; in this ſtate it is ſometimes called granitelle.

Sienite is commonly in maſs, and is rarely either ſchiſtoſe or ſtratified. It ſometimes contains metallic veins as at Altemberg in Saxony.

SILEX. *Kieſelerde.* Germ.

This earth is generally found in a ſtony ſtate, and from its forming nearly the entire compoſition of *flint*, it has acquired the name of ſilex or ſiliceous earth. It is found in equal or perhaps greater purity in rock cryſtal and quartz, and in white ſand, and on the whole it is probably the moſt abundant earth on the face of the globe. Moſt of the ſtony combinations of ſilex are remarkable for their hardneſs, and will very readily ſtrike fire with ſteel.

Silex when pure is white, and perfectly void of taſte and ſmell. It is inſoluble in water, and is incapable of artificial cryſtallization.

It likewiſe contracts but a very ſlight union with water when wetted, and is perfectly void of plaſticity, ſo that after wetting it dries more ſpeedily than any other earth. Its ſpecific gravity as it exiſts in quartz or flint is about 2.6.

It is perfectly infuſible by itſelf even in oxygen gas.

This earth is abſolutely inſoluble in every acid except the fluoric, unleſs in that ſtate of fine diviſion in which it exiſts at the moment of its ſeparation from its alkaline ſolution by acids. Its peculiar habitudes with the fluoric acid have been mentioned under that article.

The fixed alkalies readily diſſolve ſilex by the aſſiſtance of heat, and even in the cold by long digeſtion. If flint or ſand or any other ſiliceous earth in fine powder, be boiled with a ſolution of cauſtic potaſh or ſoda in which the alkaline portion is about twice the weight of the earth, after the water has entirely evaporated there remains a white puffy maſs which perfectly diſſolves in warm water into a clear ſolution. A ſimilar ſolution is formed by melting the ſilex in a moderate *red* heat with about three or four times its weight of dry carbonated potaſh or ſoda. The mixture efferveſces and ſwells violently during the fuſion, owing to the eſcape of the carbonic acid, and at laſt ſettles into a clear glaſs, which is perfectly ſoluble in water. A much ſmaller quantity of alkali, however, is able to diſſolve this earth into a perfect glaſs, in a high heat, but this is not ſoluble in water unleſs the alkali is in conſiderable exceſs. This ſolution of *Silicited Alkali*, or Liquor Silicum, as it is ſometimes called, has a ſtrong, burning, alkaline taſte. When ſaturated with an acid it becomes turbid, and the earth ſlowly ſeparates in the form of a ſpongy flocculent precipitate. If this is taken out without drying, and ſulphuric, nitric, or muriatic acid added to it, or if the firſt ſolution is at once ſuperſaturated with the acid, the ſilex is rediſſolved and the liquor becomes clear. This is much aſſiſted by large dilution with water, for the ſame proportion of acid will not rediſſolve the earth when concentrated. If this acid ſolution of ſilex is evaporated nearly to dryneſs, the whole of the ſilex ſeparates in a gelatinous form from the ſolution, and becomes as at firſt equally inſoluble in any future portion of acid, ſo that it may be waſhed and edulcorated without loſs. In this circumſtance ſilex differs from alumine, for the latter is again ſoluble in acids without further preparation. Silex thus procured is quite white, feels dry, granular, and is perfectly inſipid.

There is however a very intimate union between ſilex and alumine when in ſolution together, as has been fully explained under the article *Alumine*.

Silex, even when diſſolved in an acid or alkali gives no peculiar taſte, ſo that the ſilicited alkali has ſimply an alkaline taſte, the fluat of ſilex an acid taſte, &c.

Both barytes and ſtrontian in ſome degree diſſolve ſilex as the alkalies do, but leſs extenſively. Vauquelin mixed 200 parts of ſtrontian with 60 of ſilex,[a] heated the mixture intenſely for an hour in a platina crucible, and produced a grey, ſonorous, rifty maſs, with only a ſlight cauſtic taſte. When this was boiled in water, ſome of it diſſolved, though leſs than if it were pure ſtrontian, and it could not be cryſtallized. Saturated with nitric acid, it gave by evaporation a copious jelly, which was pure ſilex.

The ſame chemiſt alſo mixed 150 parts of barytes with 50 of ſilex, and heated them ſtrongly for an hour in a platina crucible. The reſulting maſs was of a pale apple green, forming in water a ſolution of the ſame colour, and with little taſte. This ſubſtance was alſo entirely ſoluble in moſt of the acids, and the ſolution ran into a jelly by evaporation, which was pure ſilex.

For the effect of alkalies on ſilex, ſee the article Glass.

SILICEOUS SCHISTUS. See Keiselschiefer.

SILICITED ALKALI. See the article Silex.

SILK.

This article is introduced in this place on account of a very peculiar ſalt or cryſtalline ſubſtance obtained from it by the nitric acid.

Silk in its natural ſtate (that is, before it is bleached) contains a kind of yellow reſinous matter, which gives its fine golden colour. When raw ſilk is infuſed in water, a portion of gummy matter is diſſolved, and a light amber coloured liquor is produced. Pure alcohol extracts a much deeper yellow colour, and makes a tincture that loſes none of its colour by long expoſure to the ſun, which bleaches the ſilk itſelf.[a]

Nitrous acid acts powerfully on ſilk in proportion to its concentration. If two drams of this acid are mixed with a pint of alcohol,[b] and ſilk, either raw or bleached, be immerſed in it, and kept in digeſtion in a moderate warmth for twenty-four hours, the ſilk becomes of a dull yellowiſh brown, which after rinſing and waſhing with ſoap, and drying, turns to a fine golden yellow, which is very permanent.

But when concentrated nitric acid is diſtilled off ſilk, and the remaining liquor duly evaporated, much oxalic acid is obtained, and the reſidue if evaporated ſtill further, yields along with a little remaining oxalic acid, a quantity of yellow granular cryſtals, extremely bitter, not acid, and ſtaining the ſaliva and hands of a very deep yellow not eaſily removed. If the liquor is previouſly ſaturated with potaſh and evaporated, another yellow ſilky ſalt ſeparates, which detonates on coals like common nitre, and appears to be a triple combination of the former bitter ſubſtance with nitrat of potaſh.

The firſt mentioned granular cryſtals examined with a magnifier, appear to be compoſed of truncated octohedrons.

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[a] Ann. Chim. tom. 29. p. 271.

[a] Beaumé.

[b] Ibid. An. Chim. tom. 17.

The above curious ſubſtance was diſcovered by Welter, and is by him called *the bitter principle*, and he ſuppoſes it to be generally produced by the action of nitric acid on animal matters, and is perhaps the ſame ſubſtance which cauſes the bitterneſs of bile.

It has not been further examined.

SILVANITE. See TELLURIUM.

SILVER. *Silber*, Germ. *Argent*, Fr.

Silver is a metal of a pure white colour, very malleable, ſoft, fuſible at a full red heat, but not oxydable by expoſure to the air while melted. It is ſoluble with eaſe in nitrous acid, and precipitable from its ſolution in the form of a white curd by muriatic acid, or any of the neutral muriats.

§ 1. *Ores of Silver.*[a]

Sp. 1. Native Silver. *Gediegen Silber*, Wern. *Argent Natif*, Broch.

Its colour is ſilvery white, but externally it is often yellowiſh and browniſh, in conſequence of being tarniſhed by ſulphureous vapours. It occurs maſſive, diſſeminated, in plates, in rounded pieces, alſo capillary, filiform, reticulated, arboreſcent and cryſtallized. The forms of its cryſtals are,

1. The regular octohedron.
2. The cube.
3. A ſolid, compoſed of the two former, and generally repreſented as a double ſix-ſided pyramid, with truncated ſummits.

The cryſtals are uſually very ſmall, and grouped together. The ſurface of the cryſtals is ſmooth, that of the plates is druſy, the filiform and capillary varieties are commonly longitudinally ſtriated. Its ſuperficial luſtre is metallic, varying from ſhining to glimmering, according to the ſmoothneſs or roughneſs of the ſurface. Its fracture is hackly; it acquires a bright ſhining metallic luſtre by friction. It is opake, ſoft, ductile, flexible but not elaſtic. Sp. gr. about 10.

The above is the deſcription of pure native ſilver, it is not unfrequently however alloyed with gold in various proportions; a ſpecimen analyſed by Dr. Fordyce afforded 28 per cent. of this latter metal; in this caſe the colour approaches to that of pale braſs, and its ſpecific gravity is greater than that of pure ſilver. Sometimes alſo native ſilver is mixed with a ſmall proportion of copper by which it acquires a tinge of red, and is ſenſibly harder than when pure.

The moſt recent of the primitive rocks are thoſe in which native ſilver principally occurs; it has been found alſo in ſtratified mountains. It occurs chiefly in veins accompanied by quartz, heavy ſpar, and calcareous ſpar, by various other ores of ſilver, as well as ſpathoſe iron, arſenical pyrites and cobalt, &c.

This ore is abundant in Peru and Mexico, where ſolid maſſes of ſilver have been found weighing 30 or 40 lbs. In Europe it is found moſt plentifully in Saxony, Bohemia, and Swabia. The mines of Kongsberg in Norway, which uſed to furniſh this ore are now almoſt entirely exhauſted. The Hungarian mines afford a conſiderable quantity of this ore, and it has been recently diſcovered in Cornwall. In Aſia and Africa ſilver appears to be leſs plentiful than gold.

Sp. 2. Silver Amalgam. For an account of this ore ſee MERCURY, ores of.

Sp. 3. Antimonial Silver. *Spieſglas Silber*, Wern. *Argent Antimonial*, Broch.

Its colour is tin-white, approaching more or leſs to ſilver-white; by expoſure to the air it is often ſuperficially tarniſhed, and then exhibits various irideſcent colours. It occurs in maſs, diſſeminated, in kidney-ſhaped maſſes, or cryſtallized: the forms of its cryſtals are the following.

1. The regular hexahedral priſm: ſometimes the priſm is very ſhort ſo as to become tabular: ſometimes its lateral edges are truncated, which gives it a cylindrical appearance.
2. A ſomewhat oblique four-ſided priſm, which is often nearly cubical.

The cryſtals are ſmall and very ſmall; the priſms are longitudinally ſtriated, but all the other faces are ſmooth. Externally it is gliſtening, internally it is brilliant, with a metallic luſtre. Its fracture is lamellar in one direction, but in others is flat conchoidal. It preſents granular concretions of various ſizes. It acquires a luſtre by friction; is moderately hard and brittle. Sp. gr. 9.44—10.

Before the blowpipe on charcoal this mineral readily enters into fuſion, the antimony then flies off in a white vapour, with its peculiar odour, and there remains a globule of ſilver ſurrounded with a browniſh ſlag, which colours glaſs of borax green.

It has been analyſed by Selb, Klaproth, Vauquelin and Abich, with the following reſults.

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[e] An. Chim. tom. 29.

[a] Kirwan. Emmerling. Brochant. Jameſon. Hauy.

Silver	Antim.		
89	11	Selb.	
84	14	Klapr.	The fine-grained variety from Wolfach.
76	24	Do.	The coarſe-grained from Do.
77	23	Do.	From Andreaſberg.
78	22	Vauq.	From Do.
75.25	24.75	Abich.	From Do.

It occurs in veins of calcareous ſpar and heavy ſpar, accompanied by native ſilver, galena, and occaſionally brown blende, iron pyrites, and grey copper.

It is found at Wittichen and Altwolfach, in the territory of Fürſtenberg, at Andreaſburg in the Hartz, and at Caſalla near Guadalcanal, in Spain.

Sp. 4. Arſenical Silver. *Arſenik Silber*, Germ. *Argent Arſenical*, Broch.

Its colour is tin-white, paſſing into light lead grey; it is ſuperficially tarniſhed yellowiſh or ſteel grey. It occurs in maſs, diſſeminated, in ſmall globular or kidney-ſhaped maſſes, or cryſtallized: the forms of its cryſtals are

1. The regular hexahedral priſm. Sometimes it is ſomewhat compreſſed, or rounded on its lateral edges.
2. An acute ſix-ſided pyramid with the ſummit truncated.

Internally it is more or leſs ſhining with a metallic luſtre. Its fracture is ſmall lamellar, either ſtrait or curved. The maſſive varieties preſent fine grained diſtinct concretions; the globular and kidney-ſhaped are compoſed of thin curved concentric lamellæ.

It acquires a luſtre by friction, is rather ſoft and brittle.

Before the blowpipe it melts, and the arſenic and antimony are volatilized; there remains behind an impure bead of ſilver.

A ſpecimen analyſed by Klaproth conſiſted of

Iron - - - - -	44.25
Arſenic - - - -	35.
Silver - - - -	12.75
Antimony - - -	4.
	96.

It occurs in veins of calcareous ſpar with native arſenic, red and ſulphuretted ſilver ores, galena, and blende.

It is met with at Andreaſberg in the Hartz, and Altwolfach in Swabia.

Sp. 5. Carbonated Silver. *Calciform Silver ore*, Kirw. *Luftſaures Silber*, Wid.

Its colour is greyiſh paſſing to iron black. It occurs in maſs or diſſeminated. Its luſtre is metallic, varying from glimmering to ſhining. Its fracture is fine-grained uneven, paſſing into earthy. It acquires a poliſh by friction. It is ſoft, not very brittle, and of a high ſpecific gravity.

It is fuſible with eaſe before the blowpipe into a metallic globule. Its component parts, according to Selb, are

72.5	Silver
12.	Carbonic acid
15.5	Oxyd of antimony and a trace of copper.
100.	

It was found in 1788 at Altwolfach, in a vein of heavy ſpar, with native and ſulphuretted ſilver and grey copper.

Sp. 6. Hornſilver. *Hornerz*, Wern. *Argent corné*, Broch.

Of this ore there are the two following ſubſpecies.

1 *Subſp.* Common Hornſilver.

Its colour is pearl-grey, paſſing on the one hand to milk white, and on the other to lead-grey and violet blue, ſometimes, though rarely, it has an olive or leek green tinge. It occurs in maſs, diſſeminated, ſuperficial, in roundiſh hollow balls, and cryſtallized in cubes and acicular cryſtals. The cryſtals are ſmall and very ſmall, and variouſly aggregated. Externally it is more or leſs ſhining; internally it varies from ſhining to gliſtening, and has a reſinous luſtre. Its fracture is fine-grained uneven, paſſing into flat conchoidal. It is commonly tranſlucent. It takes a poliſh by friction. It is very ſoft, ductile, and flexible when in thin plates. Sp. gr. 4.74—4.80.

When heated on charcoal by the blowpipe, it enters into ſpeedy fuſion, at the ſame time diſengaging a diſagreeable odour, and affords a globule of metallic ſilver. The maſſive hornſilver of Saxony has been analyſed by Klaproth with the following reſult.

67.75	Silver
21.	Muriatic acid
6.	Oxyd of Iron
1.75	Alumine
0.25	Sulphuric acid
96.75	

It occurs in veins of quartz, calcareous ſpar, and heavy ſpar, accompanied by native ſilver and other ores of the ſame metal, alſo by iron ochre, galena, malachite, grey copper, and cobalt ochre.

It is ſometimes inviſibly diſperſed through compact limeſtone, forming the alkaline ore of Juſti, and which contains about 2 oz. of muriated ſilver in the quintal.

Hornſilver occurs in conſiderable abundance in the Mexican and Peruvian mines: the Saxon and Bohemian mines, eſpecially thoſe of Johanngeorgenſtadt, uſed to afford great quantities of it, and it is ſtill found there, though by no means ſo plentifully as formerly. It is alſo met with at Schemnitz in Hungary, Chalanches near Allemont in France, and rarely in Cornwall.

2 *Subſp.* Earthy Hornſilver. *Buttermilcherz,* Germ.

Its colour is greeniſh-white, ſlate blue, or reddiſh brown. It occurs in thin ſuperficial cruſts, or diſſeminated. It is without luſtre. Its fracture is fine grained, earthy. It is very ſoft, almoſt friable; is brittle; acquires a ſlight greaſy luſtre by friction; it is ſomewhat unctuous to the touch.

When expoſed to the blowpipe it ſlightly agglutinates, and minute globules of ſilver make their appearance. It conſiſts, according to Klaproth, of

24.64	Silver
8.28	Muriatic acid
67.08	Alumine with a trace of copper
100.	

It occurs at Andreaſberg in the Hartz.

Sp. 6. Red Silver ore. Ruby Silver. *Rothgultigerz,* Wern. *Argent rouge,* Broch.

Its colour is carmine red, light blood red, cochineal red, paſſing into lead-grey, and iron black. It occurs in maſs, diſſeminated, in kidney-ſhaped pieces, in membranes and cryſtallized. Its primitive cryſtalline form is an obtuſe rhomboid, the plane angles of which meaſure 104° 28′ and 75° 32′: it alſo preſents

1. The ſtraight ſix-ſided priſm.
2. A ſix-ſided priſm, truncated by trihedral ſummits with rhomboidal faces.
3. The ſame as the preceding with the lateral edges of the ſummits truncated.
4. The ſame as var. 2 with the point of the ſummit replaced by a triangular plane.
5. The ſame as var. 2 with all the edges truncated.
6. A dodecahedron compoſed of two ſix-ſided pyramids, with ſcalene triangular faces joined baſe to baſe.
7. The preceding, with the pyramids (greatly lengthened) truncated and terminated by ſix-ſided pyramids with triangular faces, or trihedral pyramids with rhomboidal faces.
8. Acicular priſms.

The cryſtals are ſmall and very ſmall, and often occur in druſes. Externally they are more or leſs brightly ſhining with a luſtre between that of the diamond and ſemi-metallic. Internally this mineral is ſhining or glimmering with a ſemi-metallic luſtre. Its fracture is large or ſmall-grained uneven, alſo imperfectly and ſmall conchoidal and rarely imperfectly lamellar. The ſmall light coloured cryſtals are often tranſparent, other varieties are tranſlucent and even opake. When ſcraped it affords a powder of a bright orange-red paſſing into dull crimſon. It is ſoft, moderately brittle and eaſily frangible. Sp. gr. about 5.6.

When expoſed to the blow-pipe it crackles and flies before it becomes red-hot; it then melts with a ſlight efferveſcence emitting a yellow vapour, and at length yielding a globule of ſilver.

The light coloured variety has been analyſed by Klaproth and Vauquelin, with the following reſults,

Klapr.			Vauq.	
60.	62.	—	56.67	Silver
20.3	18.5	—	16.13	Antimony
11.7	11.	—	15.07	Sulphur
8.	8.5	—	0.	Sulphuric acid
0.	0.	—	12.13	Oxygen
100.	100.	—	100.	

It occurs in veins with quartz, calcareous ſpar, brown ſpar, native arſenic, iron pyrites, galena, blende, various ſilver ores, and occaſionally native gold. It is met with at Kremnitz and Felſobanya in Hungary, Freyberg in Saxony, Andreusberg in the Hartz, Joachimſthal in Bohemia, Guadalcanal in Spain, and St. Marie aux Mines in France.

Sp. 7. Sulphurated ſilver ore. Silber glaſerz, *Wern.* Glanzerz. *Lens.* Argent vitreux. *Broch.*

Its colour is deep lead-grey, paſſing into greyiſh black; on the ſurface it is often more or leſs irideſcent. It occurs in maſs, diſſeminated, membranous, capillary, dendritic, corroded or cryſtallized.

1. In double four-ſided pyramids, not un-

frequently truncated on the edges or ſolid angles.

2. In cubes, either perfect or truncated on the edges or ſolid angles.

3. In rhomboidal dodecahedrons.

The cryſtals are generally ſmall and variouſly grouped together. The ſurface of the cryſtals is commonly ſmooth, but ſometimes druſy. Internally it is ſhining or gliſtening, with a metallic luſtre. Its fracture is ſmall grained uneven, ſometimes flat conchoidal or imperfectly lamellar. It acquires a poliſh by friction. It is ſoft, conſiderably malleable and flexible. Sp. gr. 6.9—7.2.

Before the blow-pipe it melts, parts by degrees with its ſulphur, and affords a bead of metallic ſilver. When expoſed to a gentle heat inſufficient for its fuſion it becomes covered with filaments of metallic ſilver, as was firſt obſerved by Schreiber.

It has been analyſed by Klaproth, Sage, and Bergman, with the following reſults:

Klapr.	Sage.	Berg.
85	84	75
15	16	25
100	100	100

It occurs in veins with quartz, calcareous ſpar, heavy ſpar, native ſilver, galena, iron and copper pyrites, and blende.

The moſt ſplendid ſpecimens of this mineral come from Mexico, conſiſting of groupes of cryſtals covered with capillary native ſilver two or three inches in length; it is alſo found in Peru; in the Saxon, Bohemian, Swabian, and Hungarian mines, at Kongsberg in Norway, Schlangenberg in Siberia, and Allemont in France.

The tenacity of this mineral is ſo great, that Auguſtus, king of Poland, had ſome medals ſtruck of it.

Sp. 8. Brittle ſulphurated ſilver. Sproedglaſerz. *Wern.* Argent vitreux aigre. *Broch.*

Its colour is iron black, paſſing into ſteel and lead grey. It occurs in maſs, diſſeminated, membranous, and often cryſtallized. Its forms are,

1. The ſtrait ſix-ſided priſm with plane or convex terminations. When the priſm is very ſhort a ſix-ſided table is produced: and when the priſm intervening between the convex ſummits is ſuppreſſed the reſult is a lenticular cryſtal.

2. A ſix-ſided priſm terminated by ſix-ſided pyramids which are often deeply truncated.

The tabular cryſtals often interſect each other and thus form cellular groups. The cryſtals are generally very ſmall; their ſurface is ſometimes ſmooth, ſometimes druſy, the priſms are ſtriated longitudinally. The external luſtre of this mineral is generally very brightly ſhining; internally it varies from gliſtering to ſhining, with a metallic luſtre. Its fracture is fine grained, uneven, paſſing into ſmall conchoidal. It is ſoft, brittle, and eaſily frangible. Sp. gr. 7.2.

Before the blowpipe, on charcoal, it melts, gives out a white vapour and affords a metallic globule ſurrounded by ſcoriæ, but this globule is not malleable except by ſubſequent fuſion with nitre and borax. Its contents, according to an analyſis by Klaproth, are,

66.5	Silver
10.	Antimony
5.	Iron
12.	Sulphur
0.5	Copper and arſenic
1.	Earthy impurities
95.	

It occurs in veins accompanied by white ſilver ore (into which it often paſſes) ruby ſilver, galena, rarely cinnabar and gold. It is met with in Hungary, Tranſilvania, Saxony, Bohemia and Swabia, Norway, France, Siberia, and Peru, but is upon the whole conſiderably rarer than the preceding ſpecies.

Sp. 9. Biſmuthic ſilver. Wiſmuthiſches ſilber. *Emmerl.* Argent biſmuthifère. *Broch.* Its colour is a light lead grey which becomes deeper by expoſure to the air. It occurs generally diſſeminated, rarely in maſs. Internally it has a gliſtening metallic luſtre. Its fracture is fine-grained uneven. It is ſoft and not very brittle.

When expoſed on charcoal to the blowpipe, metallic globules begin ſoon to ooze out from it; on the addition of borax the metallic parts collect in one maſs, and the flux acquires an amber colour. The metallic button is irideſcent externally, and tin white internally; it is alſo brittle.

The contents of this ore, according to Klaproth, are,

33.	Lead
27.	Biſmuth
15.	Silver
4.3	Iron
0.9	Copper
16.3	Sulphur
96.5	

It is a ſubſtance of rare occurrence, having been found only in a mine in the valley of Shapbach in the Black Foreſt. It is accompanied by quartz, hornſtone, and copper pyrites.

Sp. 10. White ſilver ore. Weiſſgultigerz, *Wern.* Mine d'argent blanche. *Broch.*

Its colour is light lead-grey, paſſing ſometimes to ſteel-grey. It occurs in maſs and diſſeminated. Internally it has a gliſtening metallic luſtre. Its fracture is even, paſſing into fine-grained uneven; when this latter is the caſe it is generally in a ſtate of tranſition to the brittle ſulphurated ſilver (Sp. 8) ſometimes it has a tendency to the fibrous texture, and appears to be paſſing into plumoſe antimony. It gives a ſhining ſtreak; is ſoft, not very brittle; eaſily frangible. Sp. gr. 5.32.

Before the blowpipe it in part evaporates, leaving on the charcoal a ſilver bead ſurrounded with yellow powder. Both the light and dark coloured varieties have been analyſed by Klaproth with the following reſults:

Light		Dark	
48.06	—	41.	Lead
20.4	—	9.25	Silver
7.88	—	21.5	Antimony
2.25	—	1.75	Iron
12.25	—	22.	Sulphur
7.	—	1.	Alumine
0.25	—	0.75	Silex
98.09		97.25	

It is procured from the mine Himmelfurſt near Freyberg, where it occurs in veins accompanied by galena, red ſilver, brittle ſulphurated ſilver, plumoſe antimony, brown ſpar, and calcareous ſpar.

Sp. 11. Grey ſilver ore. Graugultigerz. *Klapr.*

This ſpecies has lately been introduced by Klaproth among the ſilver ores as differing eſſentially from the white ſilver ore with which it is confounded by the Hungarian miners. It occurs in maſs or diſſeminated through white quartz at Kremnitz in Hungary, and appears to be only a variety of Fahlerz or grey copper. It conſiſts, according to Klaproth, of,

14.97	Silver
31.36	Copper
34.09	Antimony
3.3	Iron
11.5	Sulphur
0.3	Alumine
95.52	

Sp. 12. Black ſilver ore. Schwarzgultigerz. *Wern.*

Its colour is iron-black, paſſing into ſteel-grey. It occurs maſſive, diſſeminated, and cryſtallized in trihedral pyramids bevilled on the edges and ſolid angles. The cryſtals are middle-ſized and ſmall. Internally it is ſhining with a metallic luſtre. Its fracture is ſmall conchoidal paſſing into uneven. It is moderately hard, brittle, and eaſily frangible.

It has not been analyſed, and appears to be a mere variety of the preceding.

Sp. 13. Sooty ſilver ore. Silberſchwarze. *Wern.* Argent noir. *Broch.*

Its colour is bluiſh-black paſſing into lead-grey. It occurs in maſs, diſſeminated, carious, ſuperficial or in rounded pieces. Its conſiſtence is between ſolid and friable. It is dull but acquires a metallic luſtre by friction. It ſtains in a ſlight degree, is ſoft, and ſomewhat malleable.

When expoſed to the blowpipe it melts eaſily into a ſlag, and by continuing the heat a portion is volatilized and there remains behind a dull looking globule of ſilver.

It has not been analyzed but is ſuppoſed to be a mixture of ſulphurated and horn ſilver in a ſtate of ſemi-decompoſition.

It occurs in veins accompanied by heavy ſpar, native, ſulphurated, and horn ſilver ores, iron ochre, malachite, and galena. It is met with at Schemnitz and Kremnitz in Hungary, Joachimſthal in Bohemia, Freyberg in Saxony, and Allemont in France.

§. 2. *Aſſay and Analyſis of Ores.*

The *Aſſay* of theſe ores having in view merely to aſcertain the proportion of ſilver which they contain, is generally conducted in the dry way. For this purpoſe the ore being roaſted and pulverized is to be mixed with litharge, in proportion to the earthy contents of the ore, and haſtily vitrified; the maſs thus produced being pulverized and mixed with black flux is to be fuſed in a crucible with a ſufficient heat; the conſequence will be that the lead of the litharge being revived will collect in a button at the bottom of the crucible, carrying with it the whole of the ſilver with ſome of the other metals that may happen to be preſent; this button together with ſuch a quantity of pure lead as may be requiſite, is to be ſubjected to cupellation, by which all the baſe metals are ſcorified, the ſilver remaining behind in a ſtate of purity, or at moſt only combined with the gold which many of the ores of ſilver contain in a ſmall proportion, and which may be ſeparated from it by methods which have been already deſcribed when treating of that metal and of the art of ASSAYING. Two or more aſſays of the ſame ore muſt be undertaken, and no dependence ought to be placed on the reſult except they very nearly correſpond.

The *analyſis* of an ore differs from its aſſay in this, namely, that its object is to aſcertain not one alone, but the whole of its ingredients, and therefore muſt be undertaken in the moiſt way. For the moſt numerous and beſt analyſes of the various ores of ſilver we are indebted to Klaproth, and as moſt of theſe are models of chemical ſkill and dexterity, we ſhall relate the particulars of them, with ſuch remarks as the ſubject may require.

1. *Hornſilver.* [c] Two hundred grains of a maſſive variety of this mineral were treated with thrice their weight of pure nitric acid, but no perceptible action took place, either in the cold or at a boiling heat, except that a little iron ochre was ſeparated. The ſolution being decanted and mixed with ammonia, an additional portion of oxyd of iron was thrown down; the ſupernatant liquor became opaleſcent on mixture with muriatic acid, but no precipitate was depoſited; hence it was manifeſt that the muriated ſilver in the ore was not mixed with any in the metallic or ſulphurated ſtate, otherwiſe it would have been taken up by the nitric acid and have afforded a precipitate with the muriatic acid. The inſoluble part of the ore was then treated with twice its weight of ſalt of tartar, and yielded 133 grains of reguline ſilver. On this preliminary information the following analyſis was founded.

a. Two hundred grains of the ore were mixed with 600 grains of cauſtic potaſh, and fuſed in a glaſs retort. After refrigeration, the neck of the retort being broken off, the fuſed mas was ſoftened with hot water, and every thing ſoluble in this menſtruum being taken up by it, the liquor was obtained clear by filtration.

b. The inſoluble portion was then digeſted in nitric acid, by which the greater part of it was taken up.

c. The part inſoluble in nitric acid was digeſted in aqua regia, and there remained undiſſolved a few grains of a white colour, which proved to be muriat of ſilver, with a little of the earthy matrix of the ore. This muriat of ſilver afforded (probably by fuſion with potaſh) 2 grs. of pure ſilver. The nitro-muriatic ſolution being decompoſed by ammonia, gave 7 grains of oxyd of iron.

d. To the nitrous ſolution (*b*) was added a ſolution of common ſalt, and the muriated ſilver thus obtained afforded by fuſion with ſoda, $134\frac{1}{2}$ grains of pure ſilver. The fluid remaining after the ſeparation of the muriated ſilver, gave by ſaturation with ammonia 5 grains of oxyd of iron.

e. The alkaline aqueous ſolution (*a*) being ſaturated with diſtilled vinegar, there precipitated $3\frac{1}{2}$ grains of alumine; which being ſeparated the liquor was evaporated to dryneſs, and the product then digeſted in alcohol, by which the acetite of potaſh was taken up, leaving the muriated potaſh behind; which latter by ſolution in water, evaporation, and cooling, yielded $117\frac{1}{2}$ grains of muriated potaſh.

f. The muriated potaſh being again diſſolved in water, there was added muriated barytes, by which a precipitate of about 3 grains of ſulphat of barytes was obtained. This is conſidered by Klaproth as indicative of $1\frac{1}{2}$ grains of ſulphated potaſh, which reduces the amount of muriated potaſh to 116 grains, in which the muriatic acid amounts to 42 grains.

From theſe reſults the contents of the ore are ſtated at *per cent.*

67.75	Silver
21.	Muriatic acid
6.	Oxyd of iron
1.75	Alumine
0.25	Sulphuric acid
96.75	

The mode of analyſis here adopted appears to be perfectly ſatisfactory, but there ſeem to be a few overſights in ſtating the reſults.

1. The ſilver is a little under-rated, its amount, according to proceſſes *c.* and *d.* being 136.5 or 68.25 *per cent.*

2. There is no notice of the oxygen, which forms an eſſential part of muriated ſilver, and in conſequence of this omiſſion, the muriatic acid is probably eſtimated much too high. The amount of the ſilver may be conſidered as aſcertained with the moſt exactneſs as it was actually reduced to the reguline ſtate. Aſſuming this therefore as the baſis of our calculations, and that 100 parts of muriated ſilver conſiſt of 75.24 ſilver, 8.16 oxygen, and 16.6 acid, it follows that 136.5 of ſilver require, in order to be converted into muriat of ſilver, 14.72 of oxygen and 30.04 of acid. But 30.04 of muriatic acid, when ſaturated with potaſh, would afford only about 84 of muriated potaſh, inſtead of 116, as

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[c] Klap. Annalyt. Eſſ. I. p. 116.

obtained by proceſs *f*. It may be added, as a further proof of the amount of this ſalt being erroneouſly ſtated, that 42 grains of muriatic acid (contained in 116 grains of muriated potaſh) indicate 253 grains of muriated ſilver, which is impoſſible, the whole amount of the ore being only 200 grains. It is probable therefore that the following corrected ſtatement of the contents of this ore is nearer the truth than that quoted above, viz.

68.25	Silver
7.36	Oxygen
15.02	Muriatic acid
6.	Oxyd of iron
1.75	Alumine
0.5	Sulphuric acid
98.88	

2. *Red Silver.*[d] This ore was analyſed by Klaproth in the following manner.

a. Five hundred grains being very finely pulverized, were digeſted for ſeveral hours at a low heat, with 6 times their weight of ſtrong nitric acid and water: a further quantity of water was then added, and the liquor was made to boil. The nitrous ſolution being poured off, the undiſſolved reſidue was treated with an equal portion of acid as at firſt, and managed in the ſame manner: the whole was then thrown on the filter, and the inſoluble matter was well edulcorated.

b. The two nitrous ſolutions with the waſhings being added together, were reduced by evaporation to ⅛ of their bulk, and the remaining liquor depoſited by cooling a conſiderable quantity of greyiſh-white cryſtals of ſulphated ſilver. The nature of theſe cryſtals being aſcertained, ſome water was added to the ſupernatant liquor, and by a gentle heat the whole was rediſſolved. The ſolution was then combined with muriatic acid as long as any precipitate was produced, and by this method muriated ſilver was obtained, which, when edulcorated and dried, weighed 391.5 grains.

c. The fluid from which the above precipitate had been obtained, was then reduced to a ſmall bulk by diſtillation, in conſequence of which it became turbid and depoſited 1 grain more of muriated ſilver: nothing now remained in the liquor except ſome ſulphuric acid.

d. The portion inſoluble by nitric acid (*a*) weighed 202 grains, and was digeſted in aqua regia, conſiſting of 5 parts muriatic acid and 1 of nitric. After the action of this menſtruum there remained 65 grains undiſſolved, which reſidue after being duly waſhed and dried, was expoſed to a gentle heat, in conſequence of which the ſulphur burnt off, leaving behind 6½ grains of muriated ſilver.

e. The nitro-muriatic ſolution after being concentrated by evaporation, was poured into a large quantity of water, upon which a white precipitate fell down, weighing, when dried, 133 grains. This was oxyd of antimony, entirely unmixed with the ſmalleſt portion of arſenic. When fuſed in a covered crucible with tartar, a button of reguline antimony was produced, and this when heated on a teſt before the bellows, was volatilized, leaving behind 0.5 grains of ſilver.

f. The reſidues of the nitro-muriatic ſolution (*e*) and of the nitric ſolution (*c*), were mixed together and diſtilled till denſe white vapours began to riſe; this concentrated fluid was then diluted with water, and muriated barytes was added as long as any decompoſition took place. The ſulphat of barytes thus obtained amounted to 194 grains.

In this analyſis the muriat of ſilver obtained amounted to 399 grains, which, being reduced to the metallic ſtate furniſhed, together with the half grain of ſilver contained in the antimony, exactly 300 grains of pure ſilver, a reſult which was confirmed by two aſſays of this ore on the cupel, each of which yielded 30 *per cent.* of ſilver.

In order to aſcertain the quantity of antimony contained in the 132 grains of white oxyd, 100 grains of reguline antimony were digeſted in warm muriatic acid, to which nitric acid was added drop by drop, till the whole of the metal was diſſolved. This ſolution being concentrated by evaporation and then poured into water, afforded 130 grains of white oxyd. Hence the above 132 grains indicate 101.5 of reguline antimony.

With reſpect to the ſulphuric acid which made its appearance in this analyſis, it is affirmed by Klaproth to have pre-exiſted, at leaſt for the moſt part, in the ore, and not to have been produced by the action of the nitric acid upon the ſulphur, for the following reaſons. In the firſt place the quantity of nitrous gas diſengaged during the action of the nitric acid on the ore is by no means ſufficient to account for the production of ſo large a quantity of ſulphuric acid. Secondly, ſome finely pulverized red ſilver ore being digeſted with ſtrong muriatic acid, the ſolution was found to contain not only antimony and ſilver but alſo ſulphuric acid. Now as muriatic acid is incapable of acidifying ſulphur it follows that the above mentioned acid muſt have pre-exiſted in the ore. This is further confirmed by an obſervation of Henkel's that the ſilver may be extracted from the red ore merely by ſucceſſive digeſtions in muriatic acid, which could not have happened without the preſence of ſulphuric acid likewiſe. We ſhall return to the conſideration of this queſtion preſently.

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[d] Klap. Analyt. Eſſ. I. 127.

The analyſis of this ore by Vauquelin[e] was thus conducted.

a. 100 parts of the ore finely pulverized were treated with 400 parts of nitric acid, and 200 of water: the colour of the mineral became by degrees grey and then paſſed into white. During the whole of this change there was no perceptible diſengagement of nitrous gas, whence it may be concluded, ſays the author, that the ingredients of the ore were already ſufficiently oxygenated to diſſolve in nitric acid. After a gentle ebullition, the whole was thrown on the filter, and the inſoluble portion after edulcoration weighed 42.06

b. The inſoluble portion was digeſted in ſtrong muriatic acid, by which its colour became yellow, and its amount was reduced to 14.66. Being then laid on a hot coal it burnt entirely with a blue flame and all the other characters of ſulphur. The ſulphur of the ore therefore may be reckoned at 14.66

c. The muriatic ſolution being poured into a large quantity of water, depoſited a white flocculent precipitate of oxyd of antimony, weighing 21.25 and compoſed, according to Vauquelin, of 16.13 antimony, and 12.12 oxygen.

d. The nitrous ſolution (*a*) was mixed with muriatic acid, and furniſhed 72.66 of muriated ſilver, equivalent, according to Bergman, to 56.67 of metal.

In this analyſis by Vauquelin there is no mention made of ſulphuric acid which was found ſo abundantly by Klaproth: and in order to bring this matter more compleatly to an iſſue, 100 parts of the ore were digeſted with a ſolution of cauſtic potaſh. As ſoon as the two ſubſtances came into contact, the colour of the ore changed firſt to grey, and preſently to a deep black; 66. parts remaining undiſſolved. Theſe were then treated with dilute nitric acid at a gentle heat, upon which a diſengagement of nitrous gas took place, and the undiſſolved matter amounted only to 8. parts, and was ſulphur. The nitric ſolution on the addition of muriatic acid afforded 70 of muriated ſilver. The alkaline ſolution, which was perfectly clear and colourleſs, gave, when treated with muriatic acid, 32. of antimonial kermes: after the ſeparation of this, the reſidual liquor was mixed with muriat of barytes without any precipitate being formed: hence it contained no ſulphuric acid. Indeed Klaproth himſelf at the concluſion of his diſſertation on this ſubject, is diſpoſed to think that the ſulphuric acid, as ſuch, does not exiſt in the ore, but that the whole of the ſulphur is in the ſtate of oxyd, and by the action of the menſtrua employed in the decompoſition of the ore, the whole of the oxygen unites with part of the ſulphur, converting it into ſulphuric acid, and leaving the remainder of the ſulphur compleatly deoxygenated. But we do not ſee how this can be the caſe: beſides it is obvious that the ſilver at leaſt muſt be in the ſtate of oxyd, ſince it diſſolves in nitric acid without producing any nitrous gas. If it were not therefore for the circumſtance that the ore when treated with ſimple muriatic acid gives out ſulphuric acid, we ſhould be diſpoſed to believe that the ore contains no ſulphuric acid, and that the oxygen is combined not with the ſulphur but with the metal.

3. *Sulphurated Silver.*

The analyſis of this ore by Klaproth is very ſimple. After being cut into ſhreds, it was digeſted with 8 times its weight of nitric acid diluted with half its bulk of water. When the action of the acid had ceaſed it was poured off, and the inſoluble reſidue being dried and weighed, was burnt on a teſt: the ſulphur was thus driven off, and there remained behind a little ſulphat of ſilver, which was then reduced to the metallic ſtate by fuſion with carbonated ſoda. The nitrous ſolution, on the addition of common ſalt, gave a precipitate of muriated ſilver, and nothing elſe remained in the liquor except a minute portion of ſulphuric acid formed no doubt by the action of the nitric acid on the ſulphur of the ore. To confirm this analyſis two aſſays were made in the dry way, and the quantity of ſilver thus obtained not only correſponded preciſely in each of them, but alſo with that procured in the analyſis.

4. *Brittle Sulphurated Silver.*

a. 100 parts of this ore when levigated were boiled in dilute nitric acid till the original black colour of the ore had changed to a greyiſh yellow.

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[e] Journ. des Mines, No. 17. p. 1.

b. To the nitrous ſolution was added a ſolution of muriated ſoda by which a precipitate of 84.75 grs. of muriated ſilver was obtained.

c. The remaining filtered ſolution was teſted with fulphat of ſoda, but no precipitation took place, thus ſhowing the abſence of lead. An exceſs of cauſtic ammonia was then added which threw down a grey precipitate weighing 5 grs. This when heated exhaled a ſlight arſenical odour, and being diſſolved in nitric acid afforded a deep blue precipitate with pruſſiat of potaſh: thus ſhowing it to be oxyd of iron with a little arſenic.

d. The ammoniacal ſolution which had a light blue colour, was ſlightly ſuperſaturated with ſulphuric acid, a poliſhed piece of iron being then inſerted was tinged with copper, but in ſo ſmall a quantity as not to be aſcertained.

e. The portion of the ore *(a.)* inſoluble in nitric acid was digeſted in nitro-muriatic acid, and the part not taken up by this menſtruum amounted to 13 grs. of which 12 were burnt off on a teſt, and were ſulphur; the remainder was ſilex.

f. The nitro-muriatic ſolution being poured into water depoſited 13 grs. of oxyd of antimony.

5. *White ſilver ore.*

a. 400 grs. of this being pulverized, were mixed with 4 oz. of ſtrong nitric acid, and 2 oz. of water. After the menſtruum had ceaſed to act it was poured off and replaced by 2 oz. of nitric acid, to which, after being digeſted for ſome time, were added 8 oz. of water, and the whole was boiled. The undiſſolved reſidue after edulcoration weighed 326 grs.

b. To the nitrous ſolution was added common ſalt by which muriated ſilver was immediately precipitated, and after a few hours were alſo depoſited cryſtals of muriated lead. The mixed precipitate was boiled with much water, by which the muriated lead was diſſolved, and the muriated ſilver obtained pure; from this by fuſion with ſoda were obtained 81.5 grs. of ſilver.

c. The two ſolutions being mixed together, there was added pure ammonia to ſaturation, which threw down a light brown ſediment, weighing 40 grains. This was rediſſolved in nitric acid, and by the addition firſt of pruſiated potaſh, and then of ſoda, was ſeparated into 12 grs. oxyd of iron and 28 alumine.

d. The undiſſolved reſidue (*a*) was boiled in repeated portions of muriatic acid, and at length there remained only 51 grs. which when ignited proved to be 49 grs. of ſulphur, and 2 grs. of a reſidue, half of which was ſilex and the other part being ſoluble in muriatic acid, was added to the other muriatic ſolution.

e. The muriatic ſolution was repeatedly evaporated till it ceaſed to depoſit cryſtals. Theſe being collected, and mixed with twice their weight of black flux, were reduced in a lined crucible, and afforded 160$\frac{3}{8}$ grs. of lead. This lead when cupelled emitted a few antimonial vapours, and left behind $\frac{1}{8}$ of a grain of ſilver.

f. The muriatic ſolution, after the muriat of lead had been ſeparated, was poured into water and depoſited a white oxyd of antimony, which being mixed with ſoap and black flux was reduced by fuſion to the metallic ſtate. In this proceſs however a ſlight portion of the antimony was volatilized; what remained weighed 31.5 grs.

6. *Grey ſilver ore.*

a. 300 grs. of this were pulverized and digeſted with four times their weight of nitric acid; when this had ceaſed to act it was poured off and replaced by another equal quantity of the ſame acid. The undiſſolved portion was of a greyiſh yellow colour, and weighed 188 grs.

b. To the bright green nitric ſolution was added a ſolution of muriated ſoda, and the precipitate thus obtained afforded by fuſion with ſoda 31.5 grs. of ſilver.

c. The ſilver being thus ſeparated, ſulphat of ſoda was added, but without occaſioning any precipitate, therefore the liquor contained no lead.

d. Cauſtic ammonia was then added to ſuperſaturation, upon which a browniſh red ſediment fell down, which when ignited weighed 9.25 grs. By digeſtion in nitric acid it diſſolved, with the exception of 0.5 gr. of ſilex. Pruſſiat of potaſh threw down from the ſolution a deep blue precipitate, after which 1.5 gr. of alumine was obtained by means of ſoda. Hence the oxyd of iron amounted to 7.25 grs.

e. The blue ammoniacal ſolution was now ſuperſaturated with ſulphuric acid, and a piece of poliſhed iron procured from it 69 grs. of copper.

f. The inſoluble portion (*a*) was boiled with ſix times its weight of muriatic acid, which being poured off when its action had ceaſed, there remained 105.5 grs. ſtill undiſſolved.

g. The muriatic ſolution being concentrated by evaporation, depoſited a little muriat of ſilver, from which 0.25 gr. of metal was obtained. The fluid being then poured into water afforded 97.25 grs. of antimonial oxyd, equivalent to 75 grs. of metal.

h. The reſidue (*f*) inſoluble in muriatic acid, weighing 105.5 grs. was ignited, and 25.25 grs. of ſulphur were thus burnt off. The remaining ſilex was then fuſed with four times its weight of black flux, and afterwards diſſolved in water, leaving behind it 0.75 gr. of ſilver. Hence the amount of ſilex was =79.5 grs.

7. *Biſmuthic Silver ore.*

Having previouſly aſcertained by roaſting that this ore contained ſulphur but no arſenic, and having obtained by cupellation from the roaſted ore 11.16 per cent. of ſilver, the analyſis was thus conducted.

a. 300 grs. were digeſted firſt with 3 oz. of nitric acid and 1 oz. of water, and afterwards with 1 oz. of the ſame acid and $\frac{1}{2}$oz. of water: 178 grs. remained undiſſolved.

b. The nitric ſolution being concentrated to the cryſtallizing point was poured into a large quantity of water, a white powder was thus obtained which proved to be oxyd of biſmuth, and weighed 44.5 grs.

c. To the filtered liquor was added muriatic acid as long as any turbidneſs enſued. The precipitate thus procured was then digeſted in moderately ſtrong nitric acid, and there remained behind 46. grs. of muriated ſilver.

d. The laſt mentioned nitrous ſolution was poured into water and afforded 32 grs. of oxyd of biſmuth, which added to the other made up 76.5 grs. equivalent to 62.2 grs. of metallic biſmuth.

e. The nitro-muriatic liquor was then evaporated till cryſtals of muriated lead began to form; ſulphuric acid was then added, and evaporation was carried on till the whole became thick. The ſulphat of lead thus obtained when waſhed and dried weighed 19 grs

f. The reſidue of the fluid was now ſuperſaturated with ammonia, which threw down oxyd of iron, which, after being rendered magnetic by roaſting with wax in a covered crucible, weighed 14 grs.

g. Into the blue ammoniacal liquor was placed a bar of clean iron, by which 2 grs. of copper were precipitated.

h. The inſoluble reſidue (*a*) being ignited loſt 37.5 grs. which were ſulphur. The remainder was boiled firſt with 3 oz. and afterwards with 1.5 oz. of muriatic acid. This ſolution being evaporated to the cryſtallizing point and then mixed with ſulphuric acid, depoſited by evaporation 89. grs. of ſulphated lead, which added to the 19. grs. in proceſs (*e*) is equivalent to 76. grs of reguline lead.

i. The reſidue, inſoluble in muriatic acid conſiſted merely of the quartzoſe matrix of the ore, and weighed after ignition 70. grs.

§ 3. *Reduction of Ores.*

Although it appears from the account which we have given of the ores of this metal that many of them when pure are very rich and mixed with a ſmall portion comparatively of other metals, yet the value of ſilver is ſo much greater than that of any other, excepting gold, as to make it well worth while to work as ſilver ores, thoſe which contain only a very minute quantity of this precious metal. Hence it is that in practice the ſilver ores contain a much larger proportion of foreign matters than thoſe of the inferior metals do, and will allow of being ſubjected with profit to much more expenſive proceſſes than can be employed for the reduction of the others.

All the different methods that are uſed may be arranged under two heads, namely, 1. The method by fuſion. 2. That by amalgamation. We ſhall begin by deſcribing the moſt ſimple of the former, and proceed to the more complex.

Reduction by Fuſion.

1. We have already mentioned under the article Lead, that galena, or the native ſulphuret of this metal, generally contains a portion of ſilver Not unfrequently this latter ingredient is in ſufficient plenty to make its ſeparation from the lead a profitable undertaking. The ſmalleſt proportion of ſilver which it is worth while to be at the trouble of extracting cannot be laid down with much accuracy, depending as it does on the market price of ſilver, of lead, of fuel, of labour, &c. We apprehend that in this country it will ſcarcely anſwer with any lead that contains leſs than 12 oz. in the ton. It is obvious that the richer the lead is in ſilver the better is it able to pay for any extraordinary care in its preparation, and of the more conſequence it becomes to extract from the ore as great a quantity of metal as poſſible, even at an expence which mere lead would be unable to ſupport.

Argentiferous galena when raiſed from the mine, is generally mixed with a larger proportion of ſtony matrix than common galena, becauſe in conſequence of the ſilver which it contains it is worth the miner's while to work much ſmaller and poorer veins of ore, than if the profit was to depend on the lead alone. It may be further obſerved that the ſilver is for the moſt part accompanied by antimony which hardens the lead and greatly deteriorates its quality except this ingredient is driven off; now the only economical method of getting rid of it is by the very ſame proceſs by which the ſilver is obtained; thus a double advantage enſues, the ſilver is ſeparated from the lead, and the lead by being at the ſame time deprived of the antimony, is rendered ſofter and more marketable.

The proportion of ſilver contained in galena is extremely variable. The richeſt that we have heard of was formerly dug in Brunghill Moor in the diſtrict of Craven in Yorkſhire; it contained about 230 oz. of ſilver per ton of lead. The Cardiganſhire mines, near Plinlimmon, in the reign of Charles I. afforded a lead which yielded 80 oz. per ton. The Durham and Weſtmoreland leads, by which the Northumberland refineries are at preſent ſupplied, yield upon the average about 17 oz. of ſilver per ton. The large refinery at Poullaouen in Brittany, is ſupplied with lead of various qualities, the average produce of which, exceeds 39 oz. per ton. Of the different proceſſes carried on at this eſtabliſhment, an excellent account has been publiſhed,[f] of which we ſhall give an abridgement, noticing at the ſame time, thoſe particulars in which it is inferior to the beſt Engliſh practice.

The ore, which is very largely mixed with gangue, is firſt dreſſed by hand and afterwards ſtamped and waſhed by means of the common apparatus. Being thus brought to the conſiſtence of ſand, and containing, beſides argentiferous galena, a ſmall portion of blende, of iron pyrites and of the earthy gangue, it is delivered to the ſmelter. The reduction of the ore is effected at two proceſſes; the firſt, which is roaſting, is performed in a common reverberatory. Here it is expoſed at firſt to a bright red heat, which however is gradually diminiſhed as the ſulphur is volatilized for fear of bringing the maſs to a ſtate of fuſion. In about an hour's time the ſurface of the ore begins to clot, which is the ſignal for turning it over with long ſpades, in order to expoſe freſh ſurfaces to the action of the heat. If this buſineſs is duly performed, in about five or ſix hours the ſulphureous vapours will have nearly ceaſed, and in conſequence, the flame playing on the ſurface of the ore will have changed from blue to reddiſh white, thus ſhewing that the roaſting is compleat. The ſecond proceſs commences by throwing upon the ſurface of the half-oxydated ore a few ſpadefuls of charcoal, and puſhing the fire vigouroufly; by this treatment, globules of melted lead begin to exude and collect in a maſs in the cavity or baſon of the furnace, with the unreduced part floating on its ſurface. In about an hour, or an hour and a half, a ſufficient quantity of melted metal is collected for the firſt running; upon which a little quicklime is thrown in, which coagulates the fluid ſcoriæ, and theſe being raked to the ſide, the baſon is pierced with an iron bar, and diſcharges the melted metal which it contains into a hemiſpherical reſervoir adjoining the furnace. The channel formed by the bar is now cloſed with clay, and in about an hour after the firſt running a ſufficient quantity of metal is collected in the baſon for a ſecond, which is performed exactly in the ſame manner as the firſt. In proportion as the ſcoriæ become more and more poor, a greater heat is required to keep them ſufficiently fluid for the globules of reduced lead to fall readily through, ſo that after from eight to nine runnings have been taken it is not worth while to expend any further quantity of fuel upon them; they are accordingly removed from the furnace, and another charge of freſh ore is immediately thrown in. The lead after it has flowed from the furnace into the reſervoir is covered with pulverized charcoal, and remains untouched for ſome time, that the ſcoriæ and other impurities may riſe to its ſurface; when this has taken place, the ſubſtances floating on the metal are ſkimmed off, and its ſurface is covered with ſawduſt and ſmall chips of wood, to which is added, by ſmall pieces at a time, about 1½ lb. of roſin; in the mean time the melted metal is ſtirred about vigorouſly to compleat its purification; as ſoon as the flame declines, the lead is removed with iron ladles, and poured into moulds. A ſingle charge of ore weighs about 26 quintals and yields about 13½ quintals of metal and more than 7 quintals of ſcoriæ, containing 30 per cent. of metal, which are reduced by a ſubſequent proceſs in a blaſt furnace.

The lead being thus extracted from the ore, the next thing to be done is to obtain the ſilver in a ſeparate ſtate which is diffuſed through the whole maſs of lead; for this purpoſe cupellation muſt be had recourſe to. In the article Assay we have noticed the theory of cupellation, and the method of performing it in the ſmall way; we ſhall here therefore only particularize the circumſtances in which cupellation in the great, or *refining* as it is uſually denominated, differs from the former. It is performed in a reverberatory furnace, the floor of which is horizontal, and is lined with a mixture of wood-aſhes and ſand, well beaten and formed into a ſhallow baſon called the cupel. At one ſide of the cupel, and forming a right angle with the flue by which the flame from the fire-place enters the cavity of the furnace, is an aperture, through which the lead flows when converted into litharge, and oppoſite to this is another aperture for the admiſſion of a blaſt of air. In the top of the furnace is a circular aperture, juſt above, and correſponding in ſize with the cupel, which may be cloſed by a frame-work of iron filled up with bricks. The furnace being ready the cupel is lined with hay, and charged with about 177 quintals of lead in bars or pigs, by means of the circular aperture juſt mentioned; the cover is then put on, and the fire is lighted. In about ſix hours the lead is entirely melted and brought to a full-red heat, at which time a blaſt of air is introduced by a metallic pipe, and ſo directed as to ſtrike upon the ſurface of the melted lead; the aſhes of the hay and other impurities are alſo removed by means of a wooden rake thruſt in at the aperture for the litharge. When the blaſt has been in action for half an hour or more, the ſurface of the lead is covered with a thick cruſt of oxyd, which being ſcraped off is preſently ſucceeded by another, and it is not till the ſurface has been cleared five or ſix times, that the true litharge makes its appearance. As ſoon as this takes place the temperature is raiſed nearly to a cherry-red, and by the action of the blaſt, the litharge with a little occaſional aſſiſtance from the workman is made to flow out of the furnace by the aperture already mentioned. A conſiderable portion of lead is alſo volatilized by the intenſe heat, ſo that the interior of the furnace is filled with vapours to ſuch a degree, that none but an experienced eye can diſcern what is going on in the cupel. In about 38 or 40 hours after lighting the fire, the contents of the cupel are diminiſhed to about 6 quintals, and the litharge which now comes over is kept ſeparate from the reſt on account of a ſmall quantity of ſilver which it contains. After a time the litharge ceaſes to flow, and the ſurface of the metal in the cupel appears to be covered only by a thin pellicle: by degrees it becomes convex at the edges, the pellicle breaks up, and the ſurface of the metal appears quite bright. The fire is now damped, the blaſt is turned off, and an aperture in the furnace, which had before been ſtopped with clay is opened to give admiſſion to a tin-plate tube, through which a ſtream of water is poured into the cupel in order to cool the metal rapidly, and thus prevent it from ſpirting, which it would do if left to itſelf at the moment of congelation.

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[f] Beaunier & Gallois in Journ. des Mines, No. 93.

The cake of metal thus procured is not however perfectly pure ſilver, and requires a ſecond cupellation at a higher heat to free it entirely from the lead with which it is mixed. The cupel made uſe of on this occaſion is a moveable one, and not capable of holding above 700 or 800 oz. It is placed in a ſmall reverberatory, and after being heated about three hours, is charged with ſilver of the firſt cupellation. A proper working heat is kept up for about four or five hours after the fuſion of the ſilver, at the end of which time the refining is uſually compleated; the contents of the cupel are then diſcharged into a mould, and thus formed into ingots. The loſs of lead by volatilization during the refining amounts to about 8 per cent.

The demand for litharge is very ſmall in compariſon to the quantity produced, the greater part of it therefore muſt be reconverted into lead; for this purpoſe it is returned to the reverberatory, and treated in the ſame manner as the ore, by which the greater part of it is converted into lead of the beſt quality, being conſiderably ſofter than when it has merely undergone the common reduction. The ſcoriæ remaining after reduction of the ore and the litharge, together with the old cupels, the metallic ſoot collected in the chimney of the furnace, &c. are laſtly treated in a common blaſt furnace, and made to yield a conſiderable portion of the lead that they contain, after which the reſidual ſlag is thrown away.

The practice in the Engliſh refineries differs from that juſt deſcribed in ſome particulars, which we ſhall proceed to notice.[b]

The furnace reſembles the common reverberatory except that its area is perforated with a large oval hole for the reception of the cupel. The cupel itſelf is thus formed: ſix parts of well-burnt bone aſhes and one part of good fern aſhes are mixed together and moiſtened to a proper conſiſtence; of this a quantity is ſtrewed to the depth of about two inches, in an iron frame, conſiſting of a raiſed elliptical rim with five broad bars rivetted to its bottom, ſo as to occupy nearly one-half of its area. By means of a wooden beater the aſhes are rammed down very cloſe, eſpecially between the bars of the frame, as it lies on a flat floor, more aſhes are then added and beaten carefully in till the frame is quite full. A cavity is then formed in the teſt by a ſharp ſpade, for the purpoſe of containing the melted metal, and at one end of the frame a ſemi-elliptical hole is cut quite through the aſhes to form a paſſage for the litharge, in forming which, care muſt be taken to leave a breaſt of ſufficient ſolidity and thickneſs between this hole and the cavity; two ſhallow channels are then made acroſs the breaſt through which the litharge may flow down the hole, and ſo eſcape out of the furnace. The teſt being thus prepared is placed in the furnace, ſo as to occupy and cover the large oval hole in its bottom, and is fixed firmly in its place with tempered clay. A gentle fire is now to be lighted and gradually increaſed till the teſt is red hot and ceaſes to emit ſteam from its under ſide: an aperture in the furnace called the feeding hole, is then opened, and the teſt is charged with melted lead, the fire is raiſed, the blaſt from a pair of double bellows is let on, and the cupellation commences. One of the channels through the breaſt of the cupel is deepened from time to time, to allow a free paſſage for the litharge; and freſh charges of melted lead are poured into the cupel, till the gutter is ſo worn as not to allow the cupel to contain more than an inch in depth of metal. The blaſt is then taken off, the old gutter compleatly filled up with moiſtened aſhes, and the baſon of the cupel repleniſhed with melted lead: the blaſt being again turned on, the litharge is directed into the channel at the other end of the breaſt, and the operation goes on as at firſt, till this gutter is likewiſe worn down, and the teſt contains no more than about 60 lbs. of metal which is let out into an iron pot, and thus this firſt part of the proceſs is compleated. The ſecond cupellation is ſimilar to the former, and not materially different from the French mode except that when the ſilver is compleatly refined, it is allowed to cool gradually, inſtead of having water poured upon it, and the conſequence is, that while congealing, a portion of ſilver ſpirts out, and is probably loſt.

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[b] Sadler in Nich. Phil. Journ. 8vo. vol. xx. p. 1.

2. As an example of the method of treating the proper ores of ſilver, we ſhall give an abſtract of the proceſſes employed at Allemont in France, under the direction of M. Schreiber.[*] The ores where rough are chiefly native ſilver, and the ſulphuret of ſilver, mixed with a little arſenical cobalt, with pyrites, with iron ochre, with clay, calcareous ſpar, and other earthy minerals. Much of the ſilver is in extremely minute grains diſperſed through the gangue ſo as to render it impoſſible to ſeparate the ſtony parts by waſhing. The ore therefore after being picked by hand is pounded dry in a ſtamping mill and is thus reduced to the conſiſtence of a coarſe ſand; in this ſtate it is aſſayed, and contains on an average about $\frac{1}{133}$ of its weight ✱ of ſilver. As it holds no ſuperfluous quantity of ſulphur there is no neceſſity for roaſting it previous to fuſion. On account of the refractorineſs of the ore, it is expedient to make uſe of quicklime, ſcoriæ from a preceding fuſion, and ſlag from the iron forges by way of flux; and in order to furniſh the proper quantity of lead of which the ore is naturally entirely deſtitute, it is mingled with pulverized galena, with the litharge and ſcoriæ furniſhed by the refinery, and with old cupels ground to powder, in ſuch proportions that the lead obtained by the fuſion ſhall contain 2 per cent. of ſilver, allowing at leaſt 20 per cent. of the lead to be loſt by evaporation or combining with the ſcoriæ. The above materials being properly mixed together are put into a powerful blaſt furnace, with alternate charges of charcoal, and the products of the fuſion are lead holding ſilver, a black compact ſulphureous ſemi-metallic ſubſtance called *Matt*, and ſcoriæ. The ſcoriæ undergo no further treatment, except that a certain portion is reſerved as a flux for the next parcel of ore; the matt being tolerably rich in ſilver is remelted with litharge, and the lead obtained carries with it nearly the whole of the ſilver, ſo that it is not worth while to fuſe again this ſecond matt, although it ſtill contains a portion of precious metal. The lead procured by theſe operations when refined yields about 2 per cent. of ſilver; the cupellation is performed at a higher heat than uſual, which perhaps is rendered neceſſary by the preſence of a little iron, the conſequence of which is, that the loſs of metal by evaporation, inſtead of being about 7 or 8 per cent. amounts at leaſt to 20 per cent. and as every pound avoirdupois of the lead thus volatilized contains from 6 to 10 grs. of ſilver, the loſs in this proceſs is prodigious, and might in all probability be greatly diminiſhed by the mixture of a much larger proportion of lead with the ſilver ore.

3. Other ſilver ores beſides this metal afford both lead and copper; and as the treatment in this caſe is the moſt complicated, we ſhall give a ſhort ſketch of it. The proceſs begins by

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[*] Journ. des Mines, No. 59, p. 1.

oz dwt gr
✱ This is 245 – 12 – 6 pr ton of 2240 lbs avoirdupois.

mixing together ſome of the poorer kinds of meagre ſilver ore (that is, ſuch as contains but little copper and lead, and much hard ſtony gangue) with the pooreſt pyritical ores (that is ſuch as contain very little ſilver and copper but much ſulphur and iron). To this is added by way of flux, a parcel of ſcoriæ remaining from a former proceſs, and containing oxyds of lead and copper with a ſmall portion of ſilver. All theſe materials being ſtrongly heated in a blaſt furnace re-act on each other and enter into fuſion; the ſtony gangue is diſſolved and the fluid maſs ſeparates into two diſtinct parts. The heavieſt portion, and which therefore occupies the bottom of the furnace, is called *matt;* it forms about ¼ of the whole maſs, and contains all the ſilver, by far the greater part of the copper, a conſiderable part of the lead, together with iron, ſulphur, and generally zinc and arſenic. The lighter portion and which ſwims on the ſurface of the matt is a black ſlag conſiſting for the moſt part of ſulphur, oxyd of iron, and earth, the lead and copper being in ſuch ſmall quantity as not to be worth the trouble of extraction; this ſlag therefore is thrown away.

The crude matt obtained by the preceding operation is roaſted to free it in part from the ſulphur and other volatile impurities, and, being mixed with about 1½ times its weight of a richer ſort of meagre ſilver ore, and about twice its weight of lead ſcoriæ by way of flux, is again fuſed, and furniſhes a rich matt (containing from 9 to 10 lbs. of lead, 3 to 4 lbs. of copper, and 6 to 7 oz. of ſilver in the quintal) and a parcel of ſcoriæ that ſtill hold a little ſilver, and are therefore employed as flux in ſubſequent fuſions.

This ſecond or rich matt, after being roaſted, is mixed with about half its weight of litharge and ſcoriæ in equal proportions, and again fuſed; the product of which is, 1. a quantity of metallic lead holding from 6 to 8 oz. of ſilver in the quintal: 2. nearly an equal amount of copper matt, holding from 30 to 40 lbs. of copper, and about 4 oz. of ſilver in the quintal; 3. Scoriæ, holding from 6 to 10 lbs. of lead, and about 40 grs. of ſilver in the quintal.

The copper matt of the preceding operation after being roaſted is fuſed together with a quantity of lead and copper ſcoriæ, and yields black copper, containing from 60 to 80 lbs. of copper, and from 5 to 10 oz. of ſilver in the quintal.

The black copper is now melted with litharge and ſcoriæ, by which the ſilver is for the moſt part transferred to the lead, and the copper after one or two more fuſions is entirely freed both from lead and ſilver, as well as from ſulphur, iron, and other impurities.

The rationale of all theſe proceſſes is ſufficiently plain. The ſilver, copper, and lead being all much more eaſily reducible than iron, are brought by means of the ſuperfluous ſulphur of the pyrites to the ſtate of ſulphuret, while the ſulphurized oxyd of iron brings the earthy matters into fuſion, forming a ſlag that is incapable of combining with the metallic ſulphurets, and through which they fall in drops on account of their ſuperior ſpecific gravity. By the proceſſes of roaſting, the ſulphur, arſenic, zinc, &c. are driven off, and the iron being oxydated quits the other metals, and unites with the ſcoriæ in the ſubſequent fuſions; while the lead, ſilver, and copper of the ſcoriæ, paſs through the vitrefied maſs, and unite with the matt. The ſeparation of the ſilver from the copper is effected by the ſuperior affinity of the former with lead, aſſiſted by the attraction ſubſiſting between the copper and ſulphur, which diſpoſes this latter metal to yield the ſilver to the lead more eaſily than if the copper was pure.

Of Eliquation.

Silver is ſometimes ſeparated from copper by *Liquation* or *Eliquation*. This is an old proceſs which appears to have fallen conſiderably into diſuſe, but it requires ſome notice in this place. When *copper matt* (or the black unrefined copper) contains ſilver in the proper proportion for this operation, it is firſt melted with lead or litharge, or a mixture of the two, and a reguline alloy is produced containing the copper, lead, and ſilver, which is caſt into moulds ſo as to form round maſſes or loaves. Theſe are then ſet in a furnace on an inclined plane of iron with a ſmall channel grooved out, and heated to a very moderate redneſs, during which the lead melts or as it were ſweats out of the loaf, and runs down the channel, conveying with it the ſilver, and the copper is left behind as a reddiſh-black ſpongy maſs. The ſilver-holding lead is then worked off on a cupel in the uſual way, and the ſilver is obtained ſeparate.

This proceſs is founded on the very weak affinity which lead has for copper, and the very ſtrong affinity which it bears to ſilver, ſo that at a moderate heat the ſeparation of the lead and ſilver from the copper is effected eaſily, but many circumſtances muſt be attended to in order to perform this proceſs with ſucceſs.

The firſt conſideration is the relative proporons of the three metals. The lead is proportioned partly to the copper and partly to the ſilver. It ſhould not be more than four times the weight of the copper, otherwiſe it will render the whole maſs ſo fuſible that inſtead of the lead and ſilver alone melting out, much of the copper will alſo mix with it, or if the heat be at all too much raiſed, the whole *loaf of liquation* will melt down, and the proceſs muſt be begun again. On the other hand the lead ſhould not be leſs than 2½ times the copper, otherwiſe a great part of it, (and along with it part of the ſilver) will remain in the loaf after heating.[i]

The above therefore are nearly the extreme limits of the relative quantities of the lead and copper, and the exact proportion of lead is determined by that of the ſilver contained in the copper, which muſt be previouſly found by a ſmall aſſay.

It is found that copper which contains more than about three quarters of a pound of ſilver in 100 lbs. will not yield all its ſilver by a ſingle proceſs of eliquation, which is doubtleſs becauſe it will not bear alloying with ſufficient lead to extract the whole, for in theſe circumſtances, according to Cramer, every half ounce of ſilver requires 17 lbs. (or 544 times its weight) of lead for its extraction, allowing four times as much lead as copper. Hence the reſpective proportions of the three metals in a loaf of liquation would be 544 parts of lead, 136 of copper, and 1 of ſilver. Theſe are nearly thoſe that are actually employed, except that a leſs proportion of lead is found ſufficient, being to the copper only as 11 to 3 inſtead of 12 to 3.

The whole proceſs of obtaining pure ſilver by liquation is managed in the following way according to the accurate account given by Duhamel.[k] It conſiſts eſſentially of five different operations. The firſt is the melting together the lead with the ſilver-holding impure copper in due proportions, and caſting the mixed alloy into the proper moulds to form the loaves of liquation. The ſecond proceſs is the *liquation*, properly ſpeaking, or the melting out from theſe loaves by a regulated heat, the lead and ſilver, and leaving the copper. The third is a ſecond roaſting of the porous loaves in order to melt out a portion of lead and ſilver, and other matters which remain after the foregoing operation. The fourth is the working off the lead on a large cupel or teſt to convert it into litharge, and leave the ſilver; and the fifth is the further purification of the ſilver by a ſecond refining with lead. Theſe two laſt proceſſes have already been deſcribed when treating of the other methods of refining ſilver. There are beſides other operations performed on the copper to refine it, and on the ſcoriæ to obtain all the metal that may adhere to them, but we ſhall here only deſcribe the three firſt proceſſes.

The fuſion of the metals is performed in a high blaſt furnace, the bottom of which is lined by a mixture of charcoal rammed hard and laid in an inclined direction ſo as to convey the metal when melted into a ſeparate receptacle adjoining. The crude black copper is previouſly broken into ſmall pieces when hot, and aſſayed for the proportion of ſilver. Either lead or litharge is uſed in the mixture, if the latter, it is mixed with charcoal to promote its reduction. The furnace being previouſly heated for eight or nine hours and filled with charcoal, a baſket-full of the ſcoriæ ariſing from the firſt reduction of the copper ore is thrown in, which ſoon melts and lines the furnace with a vitreſcent glazing that protects its walls from the violent action of the blaſt. Soon after, about 20 lbs. of lead are thrown on the hot coals, and with it about half the copper intended for one loaf of liquation: 30 lbs. of litharge are thrown upon this, and with it a ſmall baſket of charcoal to reduce it. The reſt of the copper and litharge are then added, and lead over the whole. The heat excited by the blaſt ſoon melts together theſe ingredients, reducing the litharge, and the whole falls down into the ſmall well intended for the melted metal. When enough is collected for a ſingle loaf it is tapped, and the metal is poured into an iron mould previouſly heated, and lined with a thin coating of clay. To withdraw the loaf from the mould, a ſtrong iron bar bent at top is let into the hot metal about two inches, and when cold ſerves as a handle to draw up the loaf, and is knocked away when the loaf is taken out.

The heat required in this operation is leſs than that at which copper melts, ſo that the reduction of the litharge and mixture of the metals goes on very ſpeedily. In a well managed furnace, ſeven loaves, each of about 350lbs., are caſt in an hour. Litharge is not abſolutely neceſſary, but on the whole is preferable to uſing lead alone as it is a powerful flux before reduction, and there is always a great quantity of it produced in the ſubſequent refining of the lead and ſilver. In eſtimating the proportion of the metals, 120 lbs. of litharge are taken as equivalent to 100 lbs. of lead.

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[i] Crameri Docimaſia practica: proceſſus 48.

[k] L'Art de Liquation, Mem. de l'Acad. for 1788.

Theſe proportions are nearly thoſe that have been given above. In Germany, where the works are carried on on a large ſcale, the loaves are uſually about 350 lbs. in weight, and are compoſed, when the copper is rich in ſilver, of 3 parts of black copper, (75 lbs.) and 11 parts of lead, (275 lbs). In this caſe where the ſilver is ¾ per cent. of the copper, the relative proportions of theſe metals will be about 1 part of ſilver, 132 of copper, and 488 of lead. Where the copper is poorer, only 10 parts of lead are uſed to 3 of the copper.

The next proceſs is the *Liquation*, and is performed in a furnace conſtructed for the purpoſe, which generally holds ſix loaves, ſet on iron bars, ſeparated from each other by bricks, and having a channel beneath to convey the lead and ſilver into a ſeparate baſon. The management of the heat in this proceſs is of the greateſt conſequence. If it goes on properly, the lead flows out eaſily, and the loaves gradually ſink down and become honey-combed, but without loſing any ſenſible portion of the copper. If the heat is too great, particles of the copper are ſeen to flow away along with the lead, on which the fire muſt be immediately damped. When no more lead flows out at this temperature, the loaves are taken out, and when cold they have a dark red colour, and are very crumbly. It takes about four hours to eliquate the ſix loaves.

Whatever care is taken in this proceſs there always remains a little ſilver in the loaves, which however, does not amount to more than about half an ounce in 100 lbs. when well performed. Some of the lead alſo remains, together with part of the iron, arſenic, ſulphur, and other impurities of the copper. The firſt portion of the lead that flows out of the loaves is the richeſt in ſilver, that which remains in the loaves is very poor, but ſtill is worth extracting, and is performed in the following way. When a ſufficient number of the loaves remaining after liquation are collected they are ranged in a kind of oven ſo as entirely to fill it, which takes about 150 pieces; they are then heated by the flame of charcoal and green wood, drawing through the oven till they are moderately red-hot, at which time a quantity of metal and ſcoriæ ſweat out and drop down in the hearth, conſiſting of a heterogeneous maſs of lead holding a little ſilver, of ſcoriæ, of litharge; arſenic, oxyd of iron and ſulphur, and alſo of ſome copper if the heat is raiſed too high. This maſs is waſhed with water, by which the ſcoriæ are got rid of, the ſilver-holding lead alone remains. When the droppings from the furnace begin to be red and compact, it is a ſign that all the heterogeneous matter is extracted, and that the copper itſelf begins to melt, on which the fire is removed. The loaves are then taken out, and appear varniſhed over with a thick vitreſcent ſcoria, which, on dropping them into water, cracks in every direction, and is then readily knocked off by hammers, and the copper within is found conſiderably pure. This proceſs laſts about 30 hours, half of which time is conſumed in bringing the loaves to the proper heat.

The ſubſequent proceſſes of refining the ſilver-holding lead on a teſt have been already deſcribed.

The proceſs of eliquation, though highly ingenious, is conſiderably expenſive and troubleſome, and it appears to require no ſmall degree of ſkill to conduct it properly. To be performed economically it is alſo neceſſary that the copper ſhould hold a particular portion of ſilver, (neither more nor leſs within certain limits) that is from ⅔ to ¾ per cent. of ſilver, and hence, where there are quantities of copper of different richneſs in ſilver, much judgment may be ſhewn in mixing them ſo as to produce a metal which may be eliquated with moſt profit. But where there are natural or artificial alloys of ſilver and copper much richer in ſilver than thoſe above mentioned, the proceſs of eliquation muſt be repeated two or three times on the ſame metal, which would be extremely expenſive and troubleſome.

Reduction by Amalgamation.

This moſt ingenious method of working ſilver ores, was firſt practiſed by the Spaniards in South America, and has ſince been adopted with numerous and eſſential improvements, in Saxony, Bohemia, Hungary, and ſome other parts of Europe. We ſhall proceed to deſcribe the moſt approved modern method of performing this operation.

Thoſe ores alone are amalgamated that come under the deſcription of hard or meagre; that is, which contain none, or at leaſt only an inconſiderable quantity, of lead or copper. It is of importance however, that they ſhould contain a certain proportion of iron pyrites, and if a ſufficiency of this is not naturally mingled with the ore, it is a very judicious practice to add it to the dreſſed ore, ſo that its pyritical contents ſhall always be brought to bear a certain proportion, as nearly as poſſible, to the ſilver, the amount of which latter muſt be determined by a previous aſſay.

The ore, if waſhed, is of a ſufficient degree of fineneſs, without having recourſe to grinding, but if only hand dreſſed, it muſt ſubſequently be reduced in a mill to the conſiſtence of coarſe ſand. This being done, common ſalt muſt be accurately mixed with the ore in the proportion of 8 or 9 *per cent.* if the ſilver in the ore amounts to 8 oz. per quintal, and from 10 to 12 *per cent.* if the ſilver amounts to 32 oz. or even more. The next proceſs is roaſting: for this purpoſe about 3 quintals are ſpread on the floor of a reverberatory furnace, and expoſed to a moderate red heat for four or five hours, till the emiſſion of vapours has almoſt entirely ceaſed, care being taken to turn it over two or three times during the roaſting, that every portion may be in its turn expoſed to the action of the fire. When this firſt change is withdrawn, an experienced workman can tell by its appearance whether the proportion of ſalt has been too much or too little, and the neceſſary correction is accordingly made by adding more ſalt or ore to the unroaſted parcel. The whole of the ore being properly roaſted, is ground in a mill, and afterwards paſſed through ſieves, by which it is rendered as fine as meal, and is then fit for the proceſs of amalgamation, properly ſpeaking.

This is performed in an apparatus conſiſting either of a number of ſmall barrels made to revolve rapidly on their axes by mill-work; or of a number of fixed tubs, open or covered, with an inſtrument reſembling a chocolate mill placed in the centre of each, and capable of being turned rapidly by the ſame kind of machinery as puts the barrels in motion. Theſe tubs or barrels are filled about one-third with water, and then a ſufficient quantity of roaſted ore and mercury, in nearly equal proportions, is added, to bring the whole to the conſiſtence of thin mud. The machinery is now put in motion, and is continued inceſſantly for from thirty to forty-eight hours, according to the richneſs of the ore, at which period the amalgamation is compleated. In about a quarter of an hour after the mill is ſtopped the greater part of the amalgam will have deſcended to the bottom of the veſſels, and is accordingly withdrawn, by unſtopping a hole made for that purpoſe.

The earthy reſidue is then carefully waſhed by ſmall parcels at a time, and thus much amalgam, which from its minute ſtate of diviſion was unable to ſink through and mix with the reſt, is recovered. But the earth, eſpecially if it was at firſt rich in ſilver, ſtill retains a portion of precious metal: it is accordingly dried, mixed with about 3 *per cent.* of ſalt, again roaſted, and at a higher heat than at firſt, and again amalgamated, by which the whole of the ſilver is extracted.

The amalgam, which is very fluid, is ſtrained through a cloſely-woven bag, by which it is ſeparated into nearly pure mercury, and a ſtiff amalgam: this latter is then ſubjected to diſtillation *per deſcenſum*, in an apparatus that cannot be deſcribed without the aſſiſtance of plates of reference, and is thus ſeparated into ſilver and mercury. The ſilver however ſtill contains a little copper, from which it is freed by cupellation in the uſual way.

The theory of the proceſs of amalgamation appears to be this. By the roaſting, the ſulphur of the ſilver and pyrites is for the moſt part burnt off and converted into ſulphureous acid, which acid as ſoon as formed, aſſiſted alſo by the affinity of the ſilver for muriatic acid, decompoſes the common ſalt, and forms with its baſe either ſulphat or ſulphite of ſoda, while the muriatic acid combines with the ſilver, forming luna cornea. In the ſubſequent amalgamation, the mercury being preſent in great abundance decompoſes the muriat of ſilver, and is itſelf partly converted into calomel, while the reſt of the mercury combines with the reduced ſilver into an amalgam. Hence the loſs of mercury which always happens in this proceſs depends on two cauſes, firſt, the converſion of a part of it into calomel (and this cannot by any care in manipulation be avoided) and, ſecondly, the diviſion of a part into ſuch minute globules, as enables it to paſs off unperceived in waſhing the earthy reſidue: the proportion of this however depends greatly on the care and dexterity of the manipulation.

We ſhall cloſe this ſection by mentioning in a few words a method invented by Napione,[1] of ſeparating ſilver from copper, without having recourſe to the more expenſive and tedious method of eliquation. The mixed metal being melted, ſome ſulphur is to be ſprinkled over its ſurface, while an aſſiſtant ſtirs the whole about with a ſtick; the ſulphur thus combines with the copper into a matt, which floats above the metal, and is to be removed with a pair of tongs, after having moiſtened its ſurface with a little water, in order to ſolidify it. A freſh portion of ſulphur is then to be ſtirred in, and the matt thus produced is to be removed as before; by repeating this a ſufficient number of times the greater part of the copper is converted into matt, holding a little ſilver, while the reſidual copper, by retaining moſt of the ſilver that was at firſt diffuſed through the whole maſs, becomes rich enough to be paſſed immediately to the refinery. The matt is to be ground to powder, and mixed with common ſalt and quicklime, in the proportion of 12 *per cent.* of each, and is then to be roaſted for 10 hours. This being finiſhed, it is to be amalgamated in the manner above deſcribed, and by three ſucceſſive roaſtings and amalgamations the whole of the ſilver may be extracted.

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[1] Ann. de Chim. xli. p. 160.

§. 4. *Phyſical and Chemical Properties.*

Silver is a metal of a beautiful white colour, perfectly free from taſte and ſmell. The colour is very diſtinguiſhable from that of every other metal, being a pure brilliant white, free from any other admixture of hue. Its ſpecific gravity when ſimply fuſed in maſs is about 10.4 which is ſomewhat increaſed by hammering or lamination, but leſs ſo than moſt other metals. It is a ſoft metal, being eaſily ſcratched by copper. It is conſiderably elaſtic, and when hardened by alloying, is highly ſonorous, and even in ſmall quantity much increaſes the ſonorouſneſs of the *Alloys of* Copper, as mentioned under that article. Silver is one of the moſt extenſible metals that we are acquainted with, its ductility is only leſs than that of gold, in conſequence of which it may be beaten out into extremely fine leaves, and drawn out into wire thinner than the fineſt human hair. For this latter purpoſe however a ſmall alloy of copper is found neceſſary, though leſs than that of ſtandard ſilver, which is one twelfth. Hence the ſilver procured from the ſilver and ſilver-gilt wire uſed for laces, embroidery, and other ornamental purpoſes, bears a higher price than any other uſually met with. This metal is alſo very tenacious, ſo that a wire a tenth of an inch diameter will ſupport about 240 lbs. without breaking.

Silver, when quite free from alloy, melts in a moderately intenſe red-white heat, ſo that a plate about the dimenſions of the thinneſt paſteboard, will ſcarcely ſupport the fulleſt heat of a very briſk fire in a common grate. When in fuſion, if pure, the ſurface is moſt ſtrikingly brilliant and beautiful, and like a white poliſhed mirror, but as it congeals, it becomes of a clean dead white. If cooled haſtily, the ſurface as it fixes ſhoots up into ſmall irregular projections with ſome little force, ſo as to diſperſe a few particles of that part of the metal ſtill in fuſion. Hence in the delicate buſineſs of the *aſſay* ariſes the precaution of cooling melted ſilver very gradually while it is fixing. Pure ſilver is not ſenſibly volatilized by being kept in a heat not much above its melting point for any length of time, though when mixed with another metal which is itſelf volatile, either in the metallic or oxidated ſtate, a little of the ſilver is then diſſipated. Silver is a *perfect* metal, that is, it does not oxidate by being kept in fuſion whilſt expoſed to air. This poſition however, though ſufficiently accurate for all practical purpoſes, requires ſome limitation; for when this metal is intenſely heated with acceſs of air, the ſupport on which it ſtands gradually becomes yellow, owing to the formation of an oxyd of ſilver.

The ſame change takes place, as was obſerved by Darcet, Macquer, and others, on incloſing ſilver within ſmall porcelain balls, and expoſing them to a very long continued and intenſe heat, after which a loſs of ſilver is experienced, and the earthen veſſels are found enamelled with a yellowiſh-white vitreous glazing, reſulting from the union of the vitrified oxyd with the earth of the porcelain, through whoſe pores ſufficient oxygen had entered to oxidate part of the ſilver. The pure oxyds of ſilver are however reducible to metallic ſilver by mere heat, when not in contact with any earth or other ſubſtance with which they can vitrefy, ſo that the permanence of the oxyd in this inſtance is owing to its intimate union with the earth. Under the blow-pipe, ſilver, when intenſely heated, emits copious fumes, which will render brown a ſurface of gold expoſed to it, and conſiſt of the ſilver volatilized by the extreme heat. The pure oxyd cannot be prepared by mere heat, but is readily furniſhed by the precipitation of the acid ſolutions by an alkali. In this ſtate it is inſoluble in water, free from taſte, and cannot be ſublimed, but when heated *per ſe* it returns to its metallic ſtate, except the part immediately in contact with any earthy matter which becomes fixed by vitrefying with it.

Silver is nearly unalterable by ſimple expoſure to air and moiſture, ſo that it is incapable of ruſting. A poliſhed ſurface of this metal will remain bright for ſome time in a pure air free from ſulphureous and animal vapours; by degrees however the metal becomes dull and browniſh, and after a while a very ſlight coating forms on its ſurface, which rubbing with any ſoft powder will take off, and the brightneſs will be reſtored with ſcarcely any loſs of weight, the outer coating long protecting the metal within from further change. This takes place, however, much more rapidly when the ſilver is alloyed (as in the common plate) than when pure. In general the *tarniſh* of ſilver is in too ſmall a quantity to be examined, but when this metal has been expoſed for a very long ſeries of years to the common air of towns and inhabited places, the corroſion penetrates deeper, and the altered part will readily peel off. This however is not the pure oxyd, but the ſulphuret, as was aſcertained by Prouſt, the properties of which will be afterwards deſcribed, ſo that we know of no ſimple oxyd of ſilver formed ſpontaneouſly in the air.

Water has no effect whatever on ſilver at any temperature, and is not decompoſed upon it. But when bright clean ſilver is immerſed in common natural waters, particularly thoſe that receive the refuſe of animal or vegetable matter, in no great length of time the whole becomes tarniſhed and brittle, and is converted into a ſulphuret.[m]

Though ſilver at no temperature undergoes combuſtion by ſimple contact of common air, or oxygen gas, yet it burns totally and moſt beautifully in the electric and eſpecially the galvanic circles. Silver wire or leaf applied to a powerful galvanic apparatus, burns moſt readily with an exquiſite green flame, and a denſe grey ſmoke.

The ſulphuric acid has no effect on ſilver in the cold in any ſtate of dilution, but when the acid is concentrated and a boiling heat is employed, effervefcence begins, an abundance of very pure ſulphureous acid gas is given out (as with this acid and mercury) and the metal is changed to a white pulverulent maſs, or is diſſolved entirely into a denſe clear liquid if the quantity of the acid is about four times that of the ſilver, which latter ſhould be added in ſmall ſhreds or grains.

This ſolution is extremely ſtyptic and requires an exceſs of acid. By evaporation it furniſhes ſmall white brilliant needled cryſtals.[•]

Sulphat of ſilver when heated *per ſe*, melts and ſwells up, and is not changed in a moderate heat, but, on increaſing it, blackens, exhales ſulphureous acid and oxygen, and finally returns to the pure metallic ſtate. This ſalt is ſlowly diſcoloured by light, and turns of a blackiſh brown. None of the acids except the muriatic alter it, but this, in whatever combination it be, ſeizes upon the whole of the ſilver and unites with it into that curdy ſubſtance, the muriat of ſilver or luna cornea, which will be preſently deſcribed.

With alkalies and other decompoſing ſubſtances the ſulphat of ſilver is decompoſed nearly as the nitrat. Sulphat of ſilver is alſo formed by adding to nitrat of ſilver either ſulphuric acid or any alkaline or earthy ſulphat. The reſult in either of theſe caſes is a white heavy precipitate of ſulphat of ſilver which is inſoluble in water, but with a freſh portion of ſulphuric acid forms a ſolution ſimilar to that already deſcribed.

The precipitated oxyd of ſilver diſſolves more eaſily in ſulphuric acid than the metal.

The ſulphureous acid has no action on ſilver but readily combines with its oxyd. This ſolution cryſtallizes ſpontaneouſly in ſmall pearl-grey brilliant grains, unaltered by light.[•] The ſame ſalt is procured (as in the former caſe) by adding to the nitrat of ſilver either ſulphureous acid or a ſulphite of potaſh or ſoda. The ſulphite of ammonia diſſolves the oxyd of ſilver, which it detaches from its combination with the nitric acid and (agreeably to the uſual habitudes of the ammoniacal ſalts) produces a triple ammoniaco-ſulphite of ſilver, which by expoſure to the air becomes converted into a ſulphat.

The nitric acid diſſolves ſilver eaſily, and in large quantity, and is the acid conſtantly employed for this purpoſe in the arts. The concentrated acid ſhould be diluted with from two to four parts of water. Very ſoon after the ſilver is immerſed in the acid a ſtrong efferveſcence begins, much nitrous gas is given out, which forms a copious orange-coloured vapour as it eſcapes from the veſſel, and the acid aſſumes a light blue-green colour which is independant of any copper which the ſilver may contain, and is owing to the ſolution of a portion of the nitrous gas in the acid. If however the ſilver contains copper this increaſes the blueneſs, and the colour remains after the ſolution is cold and ſaturated, which is not the caſe when the ſilver is pure. A conſiderable heat is excited by the action of the acid on the ſilver, which alſo much aſſiſts in the rapidity of the proceſs, ſo that where the quantity of each is at all conſiderable no artificial heat is required. The ſolution is made very conveniently by putting the ſilver (granulated or in ſhreds) into a decanter or matraſs, adding the acid, and to it about four parts or more of *hot* water, and ſetting it under a chimney to draw off the fumes. The ſolution then begins almoſt immediately, and goes on with increaſing violence for a time and then continues ſteadily till the ſilver is diſſolved or the acid ſaturated, without requiring any artificial heat. Towards the end however it may be boiled for a few minutes where perfect ſaturation is wanted, or where every atom of ſilver is to be ſeparated from gold as in the proceſs of parting deſcribed under the article *Aſſay*. If the effervefcence is too violent, ſo as to endanger an overflow of the contents of the veſſel, it muſt be moderated by adding cold diſtilled water.

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[m] See Wiſeman and Hatchett in Phil. Trans. vol. lxxxviii.

[•] Beaumé.

[•] Fourcroy.

When the ſilver contains a little gold as is the caſe with a large proportion of the ſtandard ſilver in uſe, the gold is left behind after the ſolution of the ſilver in the form of a black powder, which when collected, and fuſed with a little borax, appears in its reguline ſtate.

When the nitric acid contains either muriatic or ſulphuric acid a milkineſs is perceived as ſoon as the effervefcence begins, owing to the ſeparation of the firſt portions of the diſſolved ſilver from the nitric acid in the form of an inſoluble ſulphat or muriat. Where the quantity of theſe foreign acids is but ſmall, it does not materially impede the proceſs, and theſe inſoluble ſalts, after the nitric acid is fully ſaturated, fall to the bottom by ſtanding at reſt for ſome hours.

A ſmall quantity of the nitrat of ſilver is volatilized along with the nitrous gas during the ſolution, eſpecially if carried on with rapidity, and at a conſiderable heat.[p] This is proved by condenſing the vapour in a receiver, containing a clear ſolution of common ſalt, which is thereby rendered milky.

Liquid nitrat of ſilver is perfectly clear and colourleſs in caſe the ſilver was pure, but if ſtandard ſilver be employed the colour is a light blue, owing to the preſence of copper. When at all concentrated its taſte is exceſſively ſtyptic and bitter, and it rapidly corrodes the ſkin of the tongue. Even in extreme dilution the bitter ſtyptic metallic taſte, is very ſenſible, and it remains for a long time in the palate. This ſalt blackens every part of the ſkin and all other animal matters. The blackneſs however does not come on till after the part has been expoſed for ſome time to the light, and is therefore particularly haſtened by ſunſhine; but the mutual action between the ſalt and the ſkin, is ſo ſudden, when the ſolution is concentrated, that a few ſeconds of contact will be ſufficient infallibly to produce the effect though it be carefully waſhed off immediately after. This ſtain laſts for ſeveral days, and only goes off by the natural change of the cuticle, ſo that in dead animal matter it is indelible.

The blackneſs is owing to a reduction of the metal in exceſſively minute particles; for when examined in a ſtrong ſun-ſhine with a powerful microſcope the particles of metallic ſilver may be diſtinguiſhed.

Moſt vegetable ſubſtances are alſo ſtained by this ſalt, though in a leſs degree, and leſs permanently.

When this ſolution is ſufficiently concentrated it readily cryſtallizes on cooling. The form of theſe cryſtals is generally ſix-ſided, or ſquare thin plates, often ranged like the ſticks of a fan, and forming very beautiful groups. This ſalt is not deliqueſcent, and is ſoluble in about four parts of cold water and much leſs of boiling.

It appears to contain but little water of cryſtallization, for when moderately heated it melts, and may be kept at that ſtate without loſing more than one per cent. of its weight. By cooling it then concretes into a dark grey maſs, which is the nitrat ſcarcely altered, and when rediſſolved in water will again cryſtallize. This grey ſolid nitrat forms a very valuable cauſtic for the uſe of ſurgeons, and for convenience is caſt in oiled moulds into pieces about the ſize of pencils, which are called *lunar cauſtic* or *lapis infernalis*. This is actually prepared however without the trouble of cryſtallization, ſimply by evaporating the nitrat of ſilver to the proper degree, and cooling the reſidue in the proper moulds. When one of theſe pencils is broken acroſs it preſents a radiated texture. The degree of cauſticity of this ſubſtance is by no means ſo powerful as that of the ſolid alkalies, for it corrodes the cuticle with difficulty, and it requires ſome hours to deſtroy the ſurface of the fleſh.

There are two great agents which moſt powerfully decompoſe nitrat of ſilver, light and heat. Light has no action on the liquid ſolution when kept in a bottle, full and well ſtopped, but if any portion is ſpilt, and the moiſture evaporates, the remaining nitrat blackens, is decompoſed, and when diffuſed in water it is no longer entirely ſoluble, but a black powder ſubſides, which is ſilver nearly if not wholly in the reguline ſtate, and minutely divided.

Heat alſo totally decompoſes this ſalt, for if it is heated at all beyond the ſtate of lunar cauſtic, globules of reduced ſilver are found diffuſed in the maſs. By making the experiment in a glaſs retort, and a proper apparatus, the ſalt will be found to give out nitrous gas, oxygen, a little azot, and at laſt nothing remains but the ſilver, very pure, white, and ductile. If a piece of this ſalt be laid on red hot charcoal it deflagrates like common nitre, and when this is over, the charcoal is covered with a ſtrongly adhering coat of ſilver, which by a little rubbing appears of its natural colour.

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[p] Prouſt J. Phyſ tom. 62, p. 212, &c.

The compoſition of nitrat of ſilver is given by Prouſt, as follows: 100 parts of the fuſed nitrat decompoſed by heat leave 64 of pure ſilver, whence 100 parts of ſilver would form 140 of the nitrat. On the other hand 100 parts of ſilver unite with 9.5 of oxygen when oxydated in the degree in which the metal exiſts in the nitrat, whence 100 parts of the nitrat would be compoſed of about,

$$\begin{array}{lrr} \text{Silver} & \left.\begin{array}{r}64\\ 6\end{array}\right\} & 70 \\ \text{Oxygen} & & \\ \text{Nitric acid} & - & 30 \\ \hline & & 100 \end{array}$$

The actual quantity of lapis infernalis uſually obtained from ſilver is about 13 drachms from 8 drachms of pure ſilver, but only 10 or 11 drachms from the ſame quantity of ſtandard ſilver.[q]

Nitrat of ſilver detonates moſt violently with phoſphorus. If a ſmall cryſtal of nitrat of ſilver is laid on an iron anvil, and about half a grain of phoſphorus is put upon it and ſtruck ſmartly with a hammer it explodes with a very violent report. A greater quantity of theſe materials might be dangerous to the operator. The iron is found after the exploſion covered with minute particles of metallic ſilver.

Phoſphorus will alſo reduce the nitrat of ſilver in the moiſt way. Put a ſtick of newly melted phoſphorus into a very dilute ſolution of nitrat of ſilver, and in half a day it will be ſilvered on its ſurface, and gradually the whole of the ſilver precipitates on the phoſphorus in fine dendritic cryſtals.

Hydrogen alſo rapidly reduces the nitrat of ſilver, and during its reduction it paſſes through various ſhades of brown, till it acquires the metallic luſtre. A coating of ſilver may be thus fixed on ſilk, as Mrs. Fulham has obſerved in her ingenious experiments,[r] by moiſtening the ſilk and expoſing it while wet to a current of hydrogen gas. Thus placed, the ſilk becomes gradually brown, and as the reduction advances the ſurface is covered with an irideſcent pellicle of various colours whilſt a firm coating of ſilver fixes to the threads. It was found impracticable however to produce an uniform perfect ſilvering by this method, for though many particles of bright white metal may be obſerved, the general appearance is tarniſhed and void of luſtre.

Nitrat of ſilver is alſo reduced very readily upon charcoal by the ſun's rays, or by expoſure to a heat of boiling water without the aſſiſtance of light. This reduction forms ſome beautiful experiments, which are given by Count Rumford.[s] Some charcoal was firſt boiled for ſome time in diſtilled water, till it had become ſo much wetted as to ſink in this fluid. A piece of it was then introduced into a phial containing a moderately dilute ſolution of nitrat of ſilver in diſtilled water (this ſalt having been previouſly fuſed and reduced to the ſtate of lapis infernalis to drive off what little exceſs of acid the cryſtallized ſalt might contain) and it was ſet in a ſtrong ſun-ſhine. In leſs than an hour ſmall ſpecks of revived ſilver appeared on the charcoal, and this depoſition of ſilver continued till the charcoal was covered with ſpangles of reduced ſilver perfectly white and reſplendent. The ſame experiment was repeated with the difference that the phial was incloſed in a tin box and expoſed for an hour to the heat of boiling water in a common ſteamer uſed for boiling potatoes. When examined, the ſurface of the charcoal was covered with a moſt beautiful metallic vegetation, ſmall filaments of revived ſilver reſembling fine flatted wire puſhing out from the ſurface in all directions, and extending to the diſtance of a tenth of an inch.

Silver is precipitated from its nitric ſolution by mercury. If the ſolution contains both ſilver and mercury, and the precipitating metal be alſo a compound of mercury and ſilver, a curious and beautiful precipitation of a brilliant alloy of theſe two metals is depoſited in an arboreſcent form which has been called the *Arbor Dianæ* or *Silver Tree*. Lemery was the firſt who obſerved this curious metallic vegetation, and various proportions of the ingredients have been given by different chemiſts, all of which ſucceed to a certain degree. The moſt eſſential point ſeems to be, that in the ſolution the ſilver ſhould much exceed the mercury, but in the precipitant the mercury ſhould exceed the ſilver. The proportions given by

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[q] Beaumé.

[r] Eſſay on Combuſtion.

[s] Phil. Tranſ. vol. 88, p. 460.

Baumé are the following: Make an amalgam of one part of leaf ſilver with ſeven of mercury, which will unite by ſimple triture into a maſs of the conſiſtence of ſoft butter. Put a ſmall lump of this amalgam about the ſize of a bean, into a bottle containing a mixture of ſix drachms of a ſaturated nitrat of ſilver with four drachms of a ſimilar ſolution of mercury diluted with five ounces of water. Set the bottle in a place where it may remain perfectly at reſt, and the expected metallic vegetation will generally ſucceed. It begins by the appearance of ſmall ſpiculæ ſticking on the ſurface of the lump of amalgam, which after a while increaſe to broad brilliant blades elegantly arboreſcent, which, if the bottle is kept at reſt, have conſiſtence enough to keep together, and imitate a ſhrub in form.

The time required for this depends on the degree in which the ſolution is diluted; in general, with the above proportions the firſt filaments form in a few minutes, but it takes a day or two to compleat the precipitation. This precipitate is brittle, harſh to the touch, and very brilliant. The amalgam on which it is baſed loſes much of its metallic luſtre and becomes much harder than at firſt, and brittle, inſtead of being of the conſiſtence of butter. Mercury alone will anſwer the ſame purpoſe as the amalgam, but the ſilver tree is more brittle and ſooner falls down by its own weight.

Nitrat of ſilver is decompoſed by the fixed alkalies pure or carbonated, and by the alkaline earths. With the pure alkalies and earths a grey precipitate is formed, with the carbonated alkalies a yellowiſh white. In the former caſe, 100 grs. of the precipitate are produced (according to Bergman and Wenzel) by about 89 of ſilver, and in the latter by about 77.

Ammonia firſt gives a precipitate which it ſpeedily rediſſolves, and forms with ſome particulars in the management the fulminating ſilver, which will be preſently deſcribed. Carbonat of ammonia gives a white or a dark precipitate, according as it is more or leſs ſaturated with carbonic acid. All theſe oxyds turn blackiſh by expoſure to light.

Many other metals alſo ſeparate ſilver from its ſolutions in this and other acids, and particularly copper, which is employed largely for this purpoſe by the refiners. In aſſaying gold (as mentioned under the article *Aſſay*) the cupelled button of gold and ſilver is treated by nitric acid to diſſolve out the ſilver and leave the gold pure. After this proceſs (which is called *parting by aqua-fortis*) a nitrat of ſilver is left, which when a ſufficient quantity is collected is thrown into a copper baſon ſometimes alſo with pieces of copper immerſed, and the ſilver is reduced in its perfect metallic ſtate in the form of thin brittle leaves, and the baſon now contains nitrat of copper. The latter again decompoſed by lime yields the pigment *Verditer.* The whole of the ſilver is not however ſeparated by copper, for the ſolution becomes milky on adding common ſalt. The reduced ſilver alſo contains a ſmall quantity of copper. Still it is a very uſeful and convenient way of recovering the ſilver immediately in the metallic ſtate, and is employed both in the large way and in analyſis.

Nitrated ſilver is alſo decompoſed by a great variety of alkaline and earthy ſalts, particularly by the ſulphats, muriats, phoſphats, &c. that is by all thoſe whoſe acids united with ſilver produce an inſoluble ſalt. Of theſe the muriat of ſilver is the moſt important, and will be preſently mentioned.

Several of the metals are found to combine with the acids in two proportions, one, where the ingredients are in mutual ſaturation, or elſe where the acid is in exceſs, and the other where the metallic oxyd predominates. Prof. Prouſt[s] has given the following account of the nitrat of ſilver with exceſs of oxyd, or *ſub nitrat.*

It is prepared by boiling a ſaturated ſolution of the common nitrat of ſilver with reguline ſilver in that ſtate of fine flocculi in which it appears when precipitated by copper. Nitrous gas is given out during the ebullition, which is to be continued for about an hour, and the veſſel then corked and ſet by that the undiſſolved portion may ſubſide.

The ſolution is of a clear yellow colour, and is the ſub-nitrat in queſtion. Being much more ſoluble than the nitrat it may be concentrated to a much greater degree by evaporation in a retort or mattraſs into which a few pieces of ſilver are to be put to preſerve the exceſs of this metal. During the evaporation ſome of the ſalt is volatilized. It is very difficult to obtain this ſub-nitrat in regular cryſtals, for, when ſufficiently concentrated, the whole is very apt to congeal into a white ſhapeleſs maſs, during which a ſenſible heat is given out.

This ſolution differs from the common nitrat in many particulars. Its colour is yellow, but the nitrat is without colour; the ſub-nitrat changes the colour of litmus blue, and gives a blue lake with it, but the nitrat produces no effect: the nitrat turns cochineal ſcarlet; the ſub-nitrat, deep yellow: the nitrat does not change ſulphat of indigo; but the ſub-nitrat diſcolours it entirely, and the ſilver is reduced. Ammonia gives a black precipitate with the ſub-nitrat which is ſimply reguline ſilver in minute diviſion and does not fulminate; nor is the precipitate rediſſolved by an exceſs of ammonia, but the clear liquor contains oxyd of ſilver diſſolved in this alkali. When the ſolution of the ſub-nitrat is expoſed to the air, in a few days it loſes its yellow colour, and depoſits large blades of cryſtallized nitrat of ſilver. The cryſtals are then in the ſtate of common nitrat, ſo that the two ſalts differ both in the quantity of acid and of oxygen being leſs in the ſub-nitrat. If ſome drops of nitric acid are poured into the concentrated ſolution of the ſub-nitrat large cryſtals of nitrated ſilver form almoſt immediately, the yellow colour is loſt, and the whole becomes common nitrat. If the ſolution is leſs concentrated, and nitric acid is added. nitrous gas is given out.

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[s] J. Phyſ. tom. 62, p. 220.

If muriatic acid is added to the ſub-nitrat, common muriat of ſilver is precipitated, ſo that the ſupernatant liquor ought to be ſtill leſs oxygenated than before.

Water acts in a ſtriking manner on the ſolid ſub-nitrat. If *cold* water is poured on it a part only diſſolves, and the reſidue is a yellow powder, a compound of ſilver, nitric acid, and oxygen, in which the two latter ſubſtances are in ſtill ſmaller proportion to the metal than in the liquid ſub-nitrat, or the ſolid ſalt before the affuſion of water. The ſalt therefore divides itſelf into two portions, the ſoluble part abſtracting from the other a portion of its acid and its oxygen, which is nearly ſimilar to what takes place with the ſulphats of mercury during the formation of turbith, and with the nitrat of this metal. If *boiling* water is added to the ſolid ſub-nitrat, theſe changes proceed ſtill further and the inſoluble portion becomes ſucceſſively, but almoſt inſtantaneouſly, yellow, red, and black. If whilſt it is yellow or red, a few drops of nitric acid are poured in, the further change is ſtopped and the whole diſſolves into a colourleſs ſolution, but after the colour has become black, this does not take place. This black powder is merely ſilver in fine diviſion, and ſilvers the bottom of the veſſel by ſtanding.

If the ſolid ſub-nitrat is ſtill further heated in a retort, it thickens, gives out nitrous gas, fuſes, and a yellow ſublimate ariſes. No ſuch ſublimate is formed with the nitrat. The above facts ſhew that there are at leaſt two ſtates of oxydation of ſilver when in ſolution, but the ingenious diſcoverer does not give the proportions of the ſub-oxyd.

All the ſolutions of ſilver are blackened immediately by ſulphuretted hydrogen, either in the gaſſeous or liquid ſtates, and all the ſolid ſulphurets produce the ſame change on ſilver, as will be preſently mentioned.

A compound acid, extremely uſeful for diſſolving ſilver when mixed with copper and ſome other metals, has been diſcovered by Mr. Keir.[u] It is formed by diſſolving one part of nitre in about eight or ten parts by weight of ſtrong ſulphuric acid. When pieces of ſilver are thrown into this acid (undiluted with water) and a heat of from 100° to 200° is applied, an effervеſcence of nitrous gas takes place and the ſilver is diſſolved. This makes a very denſe heavy ſolution which readily concretes by cooling, but may be moderately diluted with water without becoming turbid. This compound acid (which may be termed the *nitro-ſulphuric*) diſſolves about a fifth or a ſixth of its weight of ſilver, and with much more eaſe than the ſulphuric acid ſingly would do. The quantity of nitrous gas given out in the proceſs ſeems to be leſs in proportion as that of the nitre is greater. The nitro-ſulphuric acid, undiluted, alſo oxydates and partly diſſolves tin and mercury, but it hardly touches copper, lead, gold, or iron. Hence it is particularly uſeful in recovering the ſilver from the ſurface of any ſilver plated metal, which is an object in large manufactures of plated goods, and was uſually done from copper plate at Birmingham by more expenſive methods. The preciſe proportions of ſulphuric acid and nitre are not of much conſequence. On the other hand if water is added to the acid, its power of diſſolving ſilver is much leſſened, and it then acts on copper with eaſe.

The ſilver may be recovered from the ſolution either by adding common ſalt which ſeparates it in the form of muriat of ſilver (which is afterwards reſtored to the metallic ſtate by fuſion with alkalies) or, more ſimply, by diluting the ſolution with water and continuing to immerſe the ſame pieces of copper plate which have loſt their ſilvering. The acid being now able to act on the copper will ſaturate itſelf with this metal in preference, and will depoſit the ſilver in the metallic form. The ſulphat of copper may then be applied to ſeveral uſes. The firſt way however gives a purer ſilver.

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[u] Phil. Tranſ. vol. 80.

Sulphuric acid impregnated with nitrous gas (a combination firſt noticed by Dr. Prieſtley) diſſolves ſilver with efferveſcence as ſoon as heat is applied, the ſolution becomes of a violet colour and much nitrous gas is diſengaged. By moderate dilution a white ſaline powder falls down which is rediſſolved in more water. The undiluted ſolution ſaturated, and ſet in a cool place, readily congeals, but when diluted ſlightly it gives foliated cryſtals.

The carbonic acid has no action on ſilver or its oxyd, but a carbonated oxyd inſoluble in water is formed by precipitating the nitrat or any other ſolution by a carbonated alkali. This ſubſtance is a yellowiſh white powder, which by expoſure to light, ſoon turns blackiſh, and in time it contains a ſenſible portion of metallic ſilver. It is a convenient preparation for making the ſalts of ſilver with thoſe acids, which, like the acetous, do not act on this metal in the reguline ſtate.

Muriatic acid is uſually ſaid to have no action on reguline ſilver either hot or cold. This is the fact (generally ſpeaking) for the action in a moderate time is ſo ſmall that the ſilver hardly appears corroded, though after a certain time and particularly with the aſſiſtance of heat the metal is converted into an inſoluble muriat and the remaining acid which is proportionally weakened retains ſcarcely a particle of the muriat in ſolution.[w] But the oxyd of ſilver readily unites with this acid and forms a white curd-like maſs inſoluble in water. This combination however is more frequently made by the mode of precipitation, and occurs whenever muriatic acid, or any alkaline or earthy muriat is added to any ſalt of ſilver except the pruſſiat. In this caſe if the ſolutions are at all concentrated, at the moment of mixture a white curd-like ſubſtance ſeparates, and ſpeedily ſinks to the bottom, which is the *muriat of ſilver* or *luna cornea*. This precipitation is one of the moſt familiar to chemiſts, for being perfectly inſoluble in water it ſhews itſelf when the moſt minute quantities of muriatic acid and ſilver are preſent, and thus it forms a moſt uſeful teſt for either ſubſtance.

When the quantity is extremely ſmall indeed, no actual precipitate can be collected, but the ſolutions which were limpid before mixture become more or leſs opaleſcent afterwards. Thus the pureſt natural waters contain ſome particles of common ſalt or earthy muriats, and therefore if a drop of nitrated ſilver be ſhaken with a bottle full of water, it becomes almoſt immediately milky or opaleſcent according to the quantity contained. This teſt is ſo delicate that it will even detect the minute portion of muriat of ſoda adhering to the ſkin, for if a phial containing diſtilled water with a drop or two of nitrat of ſilver be ſhaken, with the thumb uſed as a ſtopper, in a ſhort time it will have diſſolved enough of ſalt from the ſurface of the cuticle to become ſlightly opaleſcent on ſtanding.

Muriat of ſilver does not ſeparate compleatly from the liquor of the ſolution in which it is formed, till all the ſilver is precipitated, for whilſt any remains in ſolution, though the curdy precipitate is copious, the ſupernatant liquor alſo remains very milky, but as ſoon as ſufficient muriatic acid is added to engage the whole of the ſilver, the liquor becomes limpid almoſt ſuddenly. The muriat may then be collected and edulcorated with the utmoſt eaſe, more ſo than any other known precipitate. It retains the laſt portions of water however, with conſiderable obſtinacy, ſo that it cannot be thoroughly dried at the heat of boiling water, without remaining in that temperature for a conſiderable time. When perfectly dry it is in hard harſh-feeling lumps, which do not in the leaſt ſoil the fingers.

Muriat of ſilver melts at a heat ſomewhat below redneſs, (that is about the degree at which lead melts) and flows into a thin yellowiſh liquid. A ſmall portion of it volatilizes during the fuſion, but after it is melted it may be kept in a common crucible at a faint red-heat for an indefinite time without ſubliming, or ſinking through the pores of the veſſel. Neither does it attack glaſs in any degree, but at this temperature is tranſparent and has a pearl-grey luſtre which is very diſtinguiſhable. When cold it concretes into a yellowiſh, tough maſs, tranſparent in thin laminæ, flexible, which may be eaſily cut with ſciſſars, and a good deal reſembles *horn* in its appearance, whence the term *horn ſilver*, or *luna cornea*, which properly only belongs to it in this ſtate, but is indiſcriminately uſed for the muriat in any ſtate, and which we ſhall here retain. Luna cornea when cooled in maſs may be turned on the lathe, and ſnuff boxes have been made of it by the curious. When cooled ſlowly it has a ſtrong tendency to the octohedral form.[x] A ſtrong red heat volatilizes it totally in very denſe white fumes.

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[w] Prouſt.

[x] Ibid.

Muriat of ſilver when newly precipitated is of a delicate white colour, but this changes very ſpeedily and in a very ſtriking manner to a grey ſlate colour by a ſhort expoſure to light, which is an uſeful mark of diſtinction between this and many other metallic precipitates. The change however is quite ſuperficial. In a ſtrong ſunſhine it takes place very rapidly, and it was diſcovered by Scheele that when the rays are ſeparated by a priſm and thrown ſeparately on the muriat, the blackening took place in twenty-four ſeconds in the violet ray, and in an increaſing diſtance of time in the ſucceſſive colours of the ſpectrum, ſo that in the red ray, no leſs than twenty minutes were required. Mr. Ritter of Jena has ſince found that as there are inviſible heat-making rays exiſting on the outſide of the priſmatic ſpectrum beyond the red ray, (diſcovered by Dr. Herſchell, and mentioned under the article *Caloric*) ſo there are inviſible rays on the other ſide of the ſpectrum, beyond the violet ray, which poſſeſs in the higheſt degree the chemical effects known to be produced by ſenſible light, and particularly that of blackening muriat of ſilver. This was alſo diſcovered about the ſame time by Dr. Wollaſton. Mr. Ritter alſo aſſerts that if the muriat already blackened in the violet ſide of the ſpectrum, be transferred to the red ſide, the whiteneſs is partially reſtored. Theſe very curious experiments however belong more properly to the ſubject of light.

As the muriat of ſilver is produced in a great variety of analytical experiments, and ſerves to determine the quantities both of muriatic acid and of ſilver in any compound, it becomes of great importance to determine with perfect accuracy the proportion of the conſtituent parts of this ſalt. Fortunately its compoſition is ſo uniform, its inſolubility in water is ſo perfect, and the neceſſary proceſſes of edulcoration are ſo eaſy, that there is an almoſt abſolute agreement in the reſults of the experiments of different chemiſts, regard being had to the circumſtances of drying and reduction. It has been found by Klaproth that 100 parts of pure ſilver diſſolved in nitric acid, and precipitated by common ſalt, yield about 133 parts of luna cornea, dried at a heat ſuperior to that of boiling water, but ſhort of its melting point, that is to ſay, thoroughly deſiccated, but without the volatilization of any of its conſtituent parts. Other chemiſts agree very cloſely with this reſult, and from the average of thoſe that appear entitled to the moſt confidence, we may eſtimate 100 grs. of luna cornea thoroughly dried but not melted, to contain 75.235 grs. of ſilver.[y] The remaining 24.765 grs. therefore conſiſt of muriatic acid and oxygen. Of the latter, it is eſtimated by Prouſt that 100 parts of ſilver take about 9.5 during ſolution in nitric acid, and the metal probably exiſts in the ſame ſtate of oxygenation in the muriat. If this is correct, the oxygen in 100 grs. of dry luna will be about 7.15 hence the component parts will be

Muriatic acid	17.615
Silver - -	75.235
Oxygen - -	7.15
	100.000

It ſhould be obſerved however that Kirwan and other chemiſts eſtimate the quantity of oxygen taken up by 100 grs. of ſilver, to be as much as 10.8, which would make the oxygen in 100 grs. of luna cornea to be about 8.1, and would reduce the muriatic acid to about 16.6. The proportion of ſilver, however, is more certainly aſcertained, and the above eſtimation may be ſafely taken without danger of any material error.

Muriat of ſilver loſes ſome weight when paſſing from the ſtate of perfect deſiccation to fuſion, but when melted it may be kept in fuſion without further loſs, the heat not being raiſed much higher than neceſſary. Dr. Thomſon found 132.35 grs. of luna cornea dried at 400° (the product of 100 grs. of ſilver) to be reduced to 128.67 grs. by ſimple fuſion, whence 100 grs. of fuſed luna cornea may be eſtimated to contain 77.36 grs. of ſilver inſtead of 75.235 as given above.

Muriat of ſilver is nearly if not abſolutely inſoluble in any acid except the muriatic, but this acid diſſolves it without difficulty when heated, and the muriat may then be obtained in octohedral cryſtals. If this ſolution be diluted with water the muriat ſeparates in its uſual form.[z] Luna cornea is ſoluble in pure ammonia without decompoſition, and when this ſolution is evaporated in the temperature of the atmoſphere, the muriat is left either in ſmall cubes or in glittering ſcales, the latter of which reſemble very cloſely the ſuperficial ſcaly incruſtation of the native luna cornea.[a] But if the ſolution is evaporated by artificial heat, the firſt particles that fall to the bottom are the fulminating oxyd, and when ſhaken in the ſlighteſt degree will detonate with extreme violence,[b] ſo that this dangerous experiment ſhould be performed with the utmoſt caution.

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[y] Kirwan on Mineral Acids, &c.

[z] Prouſt.

[a] Klaproth.

There are various methods of reducing muriat of ſilver. The moſt frequently uſed is by carbonat of potaſh. For this purpoſe rub the dry muriat with about twice its weight of common pearl-aſh, put it into a crucible, cover it with a little more pearl-aſh, and put it into any furnace capable of giving a ſilver-melting heat. The crucible muſt be large enough to hold about twice the bulk of the materials employed. Apply heat gradually, and the maſs will firſt melt and then give off a great quantity of gas with much intumeſcence, and become quite black. Whilſt this is going on the heat ſhould not exceed a moderate redneſs, otherwiſe part of the contents are very liable to ſpurt out by the effervеſcence, after which it may be raiſed to a full white red for a few minutes, and the crucible is then to be taken off, ſtruck gently on the outſide with a hammer, to ſhake down all the ſcattered globules of metal, and cooled very gradually. On breaking it, if the reduction is well performed, it will be found to contain a clean ſaline maſs conſiſting of muriat and carbonat of potaſh fuſed into an uniform ſubſtance, and at the bottom will be a button of perfectly pure ſilver, beautifully white and reſplendent, without the leaſt diſcoloration on the ſurface, and eaſily detached from the ſaline maſs above it. It requires ſome practical ſkill to know how long to continue the fuſion, for as there is a great exceſs of carbonat of potaſh, the operator need not wait till all effervеſcence is over, but yet if the heat is urged too briſkly ſome of the luna cornea is volatilized along with part of the alkali. However, where the mere object is to procure a quantity of pure ſilver from luna cornea, it is not difficult to do it without incurring any material loſs; but when it is required for the purpoſe of analyſis to obtain *all* the ſilver from a given quantity of the muriat, more precaution is requiſite. In examining the crucible and ſaline maſs after reduction, minute globules of ſilver are ſometimes found either diſperſed through the maſs or more commonly ſticking to the ſides of the crucible. In the former caſe they ariſe either from not heating the mixture ſufficiently, or (what is more probable) from cooling it too ſuddenly, whereby the ſilver, which becomes ſolid much ſooner than the ſalt, in the moment of congealing, ſpurts up ſome globules, which penetrate and are detained in the fluid above. When the globules ſtick to the crucible it is often owing to ſome roughneſs in its ſides, which may be prevented by giving it a coating of borax by melting a little of this ſalt in it before the reduction. Small quantities of luna cornea may alſo be reduced in a dry phial ſet in ſand inſtead of a crucible, by which all the ſilver may be collected very accurately. Carbonat of ſoda anſwers as well as potaſh. Moſt of the effervеſcence may be prevented by employing the cauſtic alkalies inſtead of the carbonated, but this is expenſive in the large way. Whatever care is taken in the reduction, it is ſeldom that quite 75 parts of ſilver can be recovered from 100 of luna cornea, ſo that a ſmall portion is volatilized.

Luna cornea may alſo be reduced by mercury. This method was firſt diſcovered by Marggraf, who has alſo given the following intereſting experiments on the ſubject.[c] This excellent chemiſt firſt obſerved that ſpirit of ſal ammoniac made with ſal ammoniac and litharge, (or pure ammonia diſſolved in alcohol) diſſolved luna cornea in the cold; and a ſolution was equally effected by ſpirit of ſal ammoniac prepared from ſalt of tartar and ſal ammoniac, (or *carbonated* ammonia diſſolved in alcohol) and on adding to the latter ſolution ſix times as much mercury as it contained of luna cornea, on the next day a fine Arbor Dianæ was found in the mixture, which was a perfect amalgam of mercury and ſilver. This led him to attempt the reduction of luna cornea more directly, which he performed in the following way. Put in a glaſs mortar, one part of luna cornea, add to it about twice its weight of dry carbonated ammonia with juſt ſufficient water to bring it to the conſiſtence of ſoup, and rub them together for a quarter of an hour, during which the mixture will ſwell and effervеſce a little: then add ſix parts of the pureſt mercury revived from cinnabar, and continue the rubbing for ſome hours, during which the mixture will firſt become of a blackiſh grey, and a perfect amalgam of mercury and ſilver will be formed. Then add a quantity of water, which will become milky, and pour it off into a ſeparate veſſel before the white powder ſuſpended in it has ſubſided, leaving the amalgam in the mortar. Waſh the latter repeatedly with water, and continue rubbing, till all the white powder is rinced out, and the water returns clear from off the pure amalgam. The white powder is ſubmuriat of mercury, very ſimilar to calomel, and the ſilver has paſſed into the mercury of the amalgam, whence it may be recovered by diſtilling it *per ſe* in a retort, with a heat gradually increaſed to redneſs. A very ſmall portion of the ſilver however remains in the white powder, which may be recovered by ſublimation, in which the ſub-muriat of mercury riſes pure, and a grey powder remains, which melted with borax gives a ſmall globule of ſilver. In this way Marggraf recovered almoſt the whole of half an ounce of fine ſilver which was firſt converted into luna cornea, for the amalgam left after diſtillation half an ounce of ſilver wanting four grains, and the ſmall globule procured from the mercurial ſublimate weighed $2\frac{1}{2}$ or 3 grains more. He alſo obſerves that it is quite neceſſary to waſh out the mercurial muriat from the amalgam before the latter is diſtilled, for if it is left in, the affinities are changed at a high temperature, and luna cornea and running mercury are again formed.

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[b] Prouſt.

[c] Hiſt. de l'Acad. de Berlin for 1749.

The ſame reduction of luna cornea takes place without the labour of rubbing, by putting it along with the carbonated ammonia and mercury in a retort, adding a good quantity of water, and diſtilling to dryneſs. There remains then in the retort the amalgam and ſub-muriat of mercury, which are to be treated as above. The ammoniacal liquor which comes over may be ſaved for a future operation.

In all theſe proceſſes it is always to be remembered that it is the *carbonated* and not the *cauſtic* ammonia which is to be employed, for cauſtic volatile alkali can never be heated with muriat of mercury without danger of producing the very formidable fulminating powder, which will be preſently deſcribed.

Muriat of ſilver may alſo be reduced by fuſion with lead. Kunckel recommends mixing the muriat with thrice its weight of granulated lead and melting the mixture in a retort. It then will contain two diſtinct ſubſtances, the upper is muriat of lead, and the lower metallic ſilver, alloyed however with a good deal of lead, which muſt afterwards be ſeparated by cupellation. Prouſt obſerves in this proceſs that two parts of lead are quite ſufficient, but there is always ſome loſs of the ſilver after cupellation, as it never exceeds about 74 parts from 100 of the luna cornea. Several other of the metals will anſwer the purpoſe of the lead, but without the ſame advantages.

The habitudes of muriat of ſilver with iron and its ſalts are important. If the muriat is boiled in an iron veſſel with water, and ſome bits or filings of iron, a powder gradually collects at the bottom, which is metallic ſilver, and when heated with borax, melts into a pure button of metal. The water contains muriat of iron. The decompoſition is known to be compleat when the powder of ſilver is not blackened by expoſure to the ſun. This proceſs which is given by Sage, was repeated by Prouſt with the following reſults. A hundred parts of dry luna cornea (containing $75\frac{1}{4}$ per cent. of ſilver,) were mixed with as much iron filings, and boiled with water for ſome time in a ſilver veſſel. The powder remaining was then well waſhed and mixed with mercury to collect the ſilver. This amalgam left after diſtillation $72\frac{1}{2}$ parts of ſilver, and on adding more mercury to the powder $2\frac{1}{2}$ more of ſilver were left, making in all 75 per cent. Zinc filings will anſwer as well as iron.

Luna cornea is not decompoſed by ſulphat of iron, but it is reduced by iron in the act of ſolution in dilute ſulphuric acid, when in contact with it. Muriatic acid and iron have the ſame effect. We may here alſo make a few obſervations on the mutual action of ſulphat of iron and metallic ſilver.[d]

When the red ſulphat of iron (or that in which the metal is fully oxygenated) is *boiled* with pieces of ſilver, a portion of the metal is diſſolved ſo as to give a luna cornea with ſalt, and the ſulphat is reduced to the ſtate of the green, or *ſub-oxygenated*, ſulphat. But on keeping the ſolutions together for a time bright ſcales of metallic ſilver form in them (probably with the aſſiſtance of the light) and the ſulphat returns to its original ſtate of compleat oxygenation. On the other hand a cold ſolution of the green ſulphat mixed with ſulphat of ſilver, decompoſes the latter and metallic ſilver precipitates. Hence it appears that at a common temperature the green ſulphat takes oxygen from the ſalts and oxyds of ſilver, but when the heat is raiſed the reverſe takes place, and the red ſulphat yields oxygen to ſilver. In the latter caſe however the affinity of the oxyd of ſilver for ſulphuric acid muſt aſſiſt in the decompoſition.

Muriat of ſilver is liable to be formed whenever ſilver remains for a length of time in contact with any muriatic ſalt. Thus Prouſt found ſilver dollars deeply corroded and partly converted into muriat, by lying for many months at the bottom of the ſea on the coaſt of Spain.

The acetous acid has no action whatever upon pure ſilver, but it combines eaſily with its oxyd. Acetite of ſilver is readily formed by adding acetite of potaſh to nitrat of ſilver, or more ſimply by boiling this acid on the carbonated oxyd of ſilver. In this caſe the ſolution very readily begins to cryſtallize the moment it cools, and forms long needled cryſtals, but at the ſame time a part of the ſalt is reduced, and the maſs of cryſtals and liquor is fouled with a quantity of black powder of reduced ſilver, which however ſoon ſubſides. The clear acetite when kept in a bottle expoſed to the light is alſo partly decompoſed, and the glaſs ſoon becomes lined with a brilliant ſilvery film. Acetite of ſilver is of uſe in chemical analyſis, particularly in examining mixtures of the nitrats and muriats, where the operator wiſhes to aſcertain and ſeparate the muriatic acid without adding any extraneous nitric acid, which would be the caſe if the nitrat of ſilver were employed.

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[d] Prouſt.

When ſilver is treated with nitrous acid and alcohol, a white powder is depoſited, which fulminates with extreme violence, and which, from the analogy with the fulminating mercury produced in the ſame way, is probably an oxalat of ſilver.[c] This preparation was diſcovered by Mr. Howard, in his attempts to communicate to other metals the ſame fulminating property which he had given to mercury, and is prepared in the ſame manner as has been deſcribed in the article *Mercury*.

Mr. Cruickſhank in repeating this experiment, diſſolved 40 grains of ſilver in 2 ounces of ſtrong nitrous acid diluted with as much water, and on heating the ſolution with 2 ounces of alcohol, he obtained 60 grains of a white powder which fulminated violently. Brugnatelli has given the following method of preparing the ſame.[f] Put 100 grains of lunar cauſtic in a glaſs, and pour on them firſt an ounce of alcohol, and then as much concentrated nitrous acid. The mixture grows hot, boils, and an ether is viſibly formed, which flies off in vapour. By degrees the liquor becomes milky and is filled with ſmall white flocculi. When the liquor has thickened by this precipitation, add cold diſtilled water to ſuſpend the ebullition, otherwiſe the precipitate would be re-diſſolved, then collect the powder and dry it with a very moderate heat. This is the fulminating ſilver, and amounts to more than half the weight of the lunar cauſtic employed.

One grain placed on a lighted coal detonates with a deafening report, if touched with the end of a glaſs tube dipped in ſulphuric acid, or with the electric ſpark, ſo that in violence it greatly exceeds the fulminating mercury.

The combination of oxyd of ſilver with ammonia is remarkable for affording the moſt violently detonating ſubſtance yet known. This was diſcovered by Berthollet, and conſidering the multitude of experiments in which ammonia has been employed along with the ſalts of ſilver, it is rather ſurprizing that it was not ſooner diſcovered by ſome ſerious accident.

This fulminating ammoniacal oxyd is prepared in the following way, according to Berthollet the inventor,[g] and the directions given by Dr. Higgins:[h] diſſolve any quantity of ſilver, perfectly free from copper, in as little nitric acid, moderately dilute, as is ſufficient, pour off the clear ſolution from any black ſediment which may be left (and which is commonly gold) and add to it lime water as long as any conſiderable precipitate falls down. Edulcorate this precipitate, which is a brown oxyd of ſilver, and then lay it on ſeveral folds of filtering paper, or ſpread it out on a ſingle paper laid on a ſmooth dry lump of chalk, and dry the precipitate thoroughly in the open air. Set this oxyd by for uſe in a well-corked phial. About $1\frac{1}{10}$ oz. is obtained from an ounce of fine ſilver. The cauſtic fixed alkalies may be uſed inſtead of the lime-water, but they do not act with ſo much certainty. This oxyd diſſolved in ammonia, forms the fulminating powder. For this purpoſe add 10 or 12 grains of this oxyd to about half an ounce in meaſure of liquid ammonia, perfectly cauſtic and moderately dilute. This gives a ſnapping noiſe, and blackens the whole oxyd immediately, and diſſolves either a portion of it only, leaving a black powder at the bottom, or, if more ammonia is uſed, the whole is diſſolved. Pour the clear ſolution off from the black powder, if any, and expoſe it in a ſhallow veſſel to the air. In ten or twelve hours a cryſtalline pellicle appears on the ſurface of the ammoniacal ſolution, which is the fulminating ſilver, and is compoſed of a congeries of black ſhining cryſtals. Take them out, whilſt ſtill wet, and lay them in ſeparate parcels of not more than a grain or two on blotting paper, and let them dry in the air, carefully avoiding to touch them.

This fulminating powder has the following properties: even when ſtill wet if it be preſſed upon with a hammer or any hard body, it fulminates with extreme violence, but when dry, the touch of a ſlender wire or even a feather, or a heat of about 96°, is ſufficient to make it explode. Even a moderate concuſſion of the air is ſufficient, ſo that a heap may be exploded by the concuſſion of any other in its immediate neighbourhood. Sometimes too it will go off in the hand, when carrying from one place to another, ſo that in fact when it is once dry, the operator ſhould be prepared for the exploſion at any time, even with the moſt careful handling. A momentary flaſh is viſible at the time. If the ammoniacal ſolution poured off from the fulminating cryſtals is heated in a ſmall retort (which however is a moſt hazardous experiment) bubbles of azotic gas are given out, and ſmall opake cryſtals with a metallic ſplendour are formed, which fulminate violently when touched, even in the midſt of the liquor, and the veſſel burſts into an infinite number of fragments. When any of this ſolution touches the ſkin it blackens it for a time like nitrat of ſilver. The fulminating cryſtals when dry, appear to remain unaltered for a conſiderable time, for Fourcroy relates that he has ſeen them explode with their uſual violence, after being kept for ſome months undiſturbed.

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[c] Phil. Trans. for 1800. p. 285.

[f] Phil. Journ. 8vo. vol. vii. p. 285.

[g] Berthollet, Ann. Chem. tom i.

[h] Higgins Minutes, p. 324.

It appears probable that there are two or three varieties of this ammoniacal oxyd of ſilver, ſuch as, the black powder which ſubſides at firſt when leſs ammonia is added to the oxyd of ſilver than will diſſolve it, the fulminating cryſtalline pellicle which firſt ſeparates from the ſolution, and the black cryſtals which ſeparate when the ſolution is boiled. The firſt of theſe, the black powder, is ſtated by Dr. Higgins not to have a fulminating property, but the preciſe nature of theſe compounds has been but little examined.

It requires conſiderable care to ſucceed in producing the fulminating ſilver. The metal ſhould be quite free from copper, the oxyd produced by lime ſhould be thoroughly edulcorated, and eſpecially the ammonia ſhould be quite free from carbonic acid. Carbonat of ammonia does indeed diſſolve the oxyd of ſilver with ſome efferveſcence, owing to the eſcape of part of the carbonic acid, but with the remainder a triple ammoniaco carbonated oxyd of ſilver is formed, which will not fulminate.

Several ſerious accidents have happened in preparing this fulminating ſilver which ſhew the neceſſity of great precaution in the operator, and as all the circumſtances in which the exploſion is produced are not as yet known, he ſhould on no account venture to prepare more than a few grains at a time of this dangerous compound. Dr. Higgins mixed together 24 grains of the oxyd of ſilver with a quarter of an ounce of water *ſaturated* with ammoniacal gas in a corked bottle, which produced a blue ſolution with the expulſion of ſome gas, and without the formation of any pellicle, and ſix hours afterwards, on ſhaking the bottle to compleat the ſolution of a little blackened oxyd which lay at the bottom, the whole exploded with exceſſive violence, the bottle was quite reduced to powder, and his hand was numbed as if with the blow of a heavy hammer. In this caſe it appears probable that this unexpected exploſion aroſe, partly from uſing too concentrated a ſolution of ammonia, too large a quantity of ſilver, and eſpecially from ſhaking the contents of the bottle. Another accident is mentioned in the Journal de Phyſique[i] where the preparation ſeems to have been conducted with perfect prudence and accuracy, and an ammoniacal ſolution was made, which contained apparently about five grains of the fulminating cryſtals, but on dipping a card into it to take out the cryſtals, the whole exploded with exceſſive violence, which had nearly deprived the operator of his ſight. The only difference from the common way of operating in this caſe appeared to be that the cryſtals were allowed to remain in the ſolution twenty-four hours after mixture, inſtead of being taken out as ſoon as they appeared.

It has been already mentioned that this fulminating ſilver is alſo produced when *muriat* of ſilver is boiled with pure ammonia, and explodes in the act of formation, and hence ariſes another precaution in applying artificial heat to any mixture of ammonia and oxyd of ſilver free from carbonic gas.

Silver is capable of uniting with ſulphur in various proportions. Artificial ſulphuretted ſilver is a black brittle maſs, like the native ſulphuret. The utmoſt proportion of ſulphur capable of uniting with ſilver is ſtated by Wenzel[k] to be 13 of the former to 87 of the metal. Yet the following experiment by the late Mr. Alchorne, ſeems to ſhew that the ſilver does not eaſily retain much more than half this quantity at a moderate red heat. Half an ounce (240 grains) of ſilver precipitated from the nitrat by copper was mixed with its own weight of ſulphur, and put into a crucible with another inverted over it, and luted, leaving a ſmall hole for the eſcape of the ſuperfluous ſulphur. On applying a red heat, part of the ſulphur eſcaped and burned off at the hole. The fire was increaſed to a degree which was judged ſufficient to melt the maſs within, and kept up till the blue flame diſappeared. When cold, a dark lead-coloured brittle button was found in the crucible, which was ſoft enough to be cut with the knife, and exactly reſembled the vitreous ſilver ore. The ſilver had gained 20 grs. or $\frac{1}{12}$ in weight, whence the proportion of ſulphur in this artificial ſulphuret is about 7.7 grains in 100.

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[i] Tom. 58, p. 362.

[k] Kirwan's Mineralogy, vol. 2.

A ſulphuret, or rather a hydro-ſulphuret of ſilver is alſo formed whenever this metal is expoſed to ſulphureous vapours, or any liquid containing ſulphuretted hydrogen. After a certain time the ſubſtance of the metal is deeply ſulphuretted, and may be detached in brittle ſcales. But it takes a great length of time to effect this by mere expoſure to ſulphureous vapours.

The ſuperficial *tarniſhing* which ſilver plate undergoes when laid by for ſome time, or more ſuddenly, when in contact with animal matters, is probably owing to this change, but it long remains only ſuperficial.

The inſtant precipitation of a black hydroſulphuret in all the ſalts of ſilver produced by the addition of a liquid ſulphuret or gaſſeous ſulphuretted hydrogen, has been already mentioned.

Silver unites with phoſphorus though weakly. Pelletier[l] obtained this phoſphuret by mixing in a crucible half an ounce of ſilver in fine diviſion, 2 drachms of powdered charcoal, and an ounce of vitrified phoſphoric acid, and giving it a full heat for half an hour. On opening the crucible the fuſion was compleat, and on cooling, many luminous jets of phoſphorus came from the ſilver in the act of ſolidifying. The ſilver had gained a drachm in weight, had loſt its ductility, had a granular and cryſtallized texture, and was brittle. It remained white, and ſoft enough to be cut by the knife. When melted on a cupel the whole of the phoſphorus burned off, and the ſilver remained pure.

Some of the alloys of ſilver are important. This metal will unite with ſome metals perfectly and without loſing its malleability; with others it forms a brittle white alloy, but with others it refuſes to unite except in a very minute proportion.

Silver mixed with gold, dilutes its yellow colour more or leſs according to its quantity.[m] Gold with $\frac{1}{20}$ of ſilver is ſenſibly paler, and the debaſement of colour proceeds pretty uniformly as the ſilver is increaſed. Theſe mixtures are very malleable though ſomewhat firmer, harder, and more ſonorous than either metal ſeparately. In this reſpect, as in the colour, a little ſilver affects gold more than a little gold does ſilver. On account of the ſuperior price and the alteration of colour, ſilver is never intentionally alloyed with gold, but a large portion of the American ſilver naturally contains a ſmall quantity of gold, which remains as a fine black ſlime or ſediment when the ſilver is diſſolved in aqua fortis.

Homberg mentions in the Memoires de l'Acad. des Sciences for 1713 a curious experiment to ſhew that in certain circumſtances a ſeparation may take place between theſe two metals. He melted equal parts of gold and ſilver in a crucible with a little ſea-ſalt and nitre for a quarter of an hour, and when cold, the gold was found at the bottom in one lump, but retaining about a ſixth of ſilver, and above was the remainder of the ſilver in a ſeparate button quite pure. He obſerves that this experiment only ſucceeds with nearly equal quantities of the two metals, and with a fire not too long continued. If this be accurate, there appears a point of ſaturation of one metal with the other reſpectively, but the experiment has not been repeated, nor does it agree with thoſe authors who aſſert that the two metals produce an uniform alloy in any proportions.

The curious effect produced on ſilver by being alloyed with platina has been already deſcribed under the article *Aſſay*, p. 118, and that of *Platina*.

Copper is the metal uſually employed to alloy ſilver in the vaſt quantity of this metal uſed for coin and plate of all kinds. The ſtandard ſilver of this country is compoſed of eleven parts of ſilver and one of copper. In this proportion or even ſomewhat more of the alloy, the mixture remains nearly as white as pure ſilver, but is much harder, leſs fuſible, and though it remains highly malleable and ductile ſo as to bear being extended into any ſhape, and wrought in a thouſand different ways, it is certainly leſs ductile and malleable than a metal with leſs alloy, ſince ſuch a finer metal is required to be uſed in making ſilver wire and leaf. On account of the hardneſs given by the copper alloy it is much better fitted to take a fine impreſſion, and is therefore particularly uſeful in coining, and in all domeſtic implements.

An alloy of theſe two metals has been uſed in France for coinage for many years, and called *monnaie de billon*, in which the ſilver is from $\frac{1}{12}$ to $\frac{1}{4}$ of the maſs, and which looks like half-whitened copper, or degraded ſilver. Being on the whole an injudicious compound it is moſtly now laid aſide. When ſilver and copper are in equal parts, the alloy is ſtill very yellow, but may be united with about 4 or 5 per cent. of arſenic, and ſtill remain very malleable, with the advantage of being much whitened by the mixture. Vauquelin[n] has alſo found that a larger doſe of arſenic, does not increaſe the whiteneſs, but rapidly impairs the malleability, and when the arſenic amounts to 10 per cent. the alloy is ſo harſh and brittle as not to bear laminating.

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[l] Memoires, tom. 1.

[m] Lewis's Commerce of Arts.

Silver unites perfectly with lead apparently in every proportion, into an uniform malleable mixture, harder and whiter, and leſs fuſible than pure lead, in proportion to the quantity of ſilver. This mixture is formed in the proceſs of *Eliquation* (already deſcribed in this article) whence it appears that the affinity of ſilver for lead is ſuperior to that of ſilver for copper. The neceſſity of this alloy to the proceſs of cupellation in *aſſaying* and in refining ſilver has been already mentioned.

Silver and iron are generally reckoned entirely to refuſe to unite in any proportions, and it is certain that when they are melted together, they form, on cooling, two perfectly diſtinct and ſeparable buttons, the iron at top, and the ſilver beneath it. Yet a certain degree of alloying takes place as is proved by the following curious experiment of Guyton on this ſubject.[•] In a crucible lined with charcoal, 15 parts of pure ſilver, reduced from luna cornea, were mixed with as much fine iron filings, and a flux compoſed of glaſs, charcoal duſt, and a little borax. This was kept for an hour in a heat of 150° to 155° *Wedgewood*, and on cooling, a button was found with ſome traces of cryſtallization on the ſurface, but which ſeparated moſt accurately into two buttons of very different compoſition. A part of the lower button, diſſolved in nitric acid, gave only a white precipitate, and not a blue one, with pruſſiat of potaſh, and appeared to be perfectly pure ſilver, but the metal was found to be pretty ſtrongly magnetical, and therefore contained a very ſmall portion of iron, which was eſtimated by Coulomb to be about $\frac{1}{320}$. The upper button, which appeared to be pure iron, was exceſſively hard, very difficultly frangible, and when diſſolved in nitric acid gave a copious precipitate of luna cornea with ſalt, the quantity of which indicated an alloy of about $\frac{1}{80}$ of ſilver.

Silver unites with biſmuth, zinc, antimony, and ſome other of the brittle metals, forming brittle alloys which have not been much examined, and are of little importance.

The affinities of the oxyd of ſilver for the different acids are in the following order: the muriatic, oxalic, ſulphuric, phoſphoric, nitric, arſenic, fluoric, tartareous, citric, acetic, and carbonic.

SILVERING, *the Art of.*

This art conſiſts in covering the ſurface of ſubſtances with a thin coating of ſilver. There are two motives for this; in the firſt place, the ſuperior beauty of ſilver to that of the cheaper metals; and in the ſecond place its ſuperior wholeſomeneſs to copper, braſs, or lead, for culinary purpoſes on account of its not being acted upon by vinegar and other weak acids.

As an ornament, ſilver is far inferior to gold, from its great liability to be blackened by ſulphureous vapours, which renders frequent cleaning abſolutely neceſſary; hence it is inapplicable to the purpoſe of architectural decoration, and is ſcarcely ever applied except to utenſils and ornaments of metal. From the frequent neceſſity of friction for the purpoſe of removing the tarniſh of ſilver it is neceſſary that it ſhould be much thicker than the moſt ſolid gilding, otherwiſe, after a ſhort time, the ſilver will be worn off the moſt prominent parts, diſcovering to view the copper or braſs beneath.

The only metals that are ſilvered are copper, braſs, and very rarely iron.

There are three modes of ſilvering, namely, by ſilver amalgam, by muriated ſilver, and by ſilver in ſubſtance.

1. *Silvering by amalgamation* is thus performed:

To a ſolution of nitrated ſilver add ſome plates of copper which will throw down the ſilver in its metallic ſtate, and very finely divided; ſcrape it from the ſurface of the copper, waſh it well and dry it. Of this powder take half an ounce, of common ſalt and ſal ammoniac 2 ounces, and of corroſive ſublimate one drachm, rub them well together, and make them into a paſte with a little water. Then take the veſſel to be ſilvered, and clean it by means of a little very dilute aquafortis, or by ſcouring it with a mixture of common ſalt and tartar. When it is perfectly clean, rub it with the above-mentioned paſte till it is entirely covered with a white metallic coating; this coating is an amalgam produced by the decompoſition of the corroſive ſublimate by means of the copper, to the ſurface of which it applies very cloſely and expeditiouſly. The copper being thus ſilvered over is to be waſhed, dried, and afterwards heated nearly red, in order to drive off the mercury; the ſilver remains behind adhering firmly to the copper, and capable of being highly poliſhed.

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[n] An. Chim. tom. 39, p. 265.

[•] Ibid. tom. 43.

2. *Silvering by luna cornea.*

Prepare the luna cornea in the uſual manner by pouring a ſolution of common ſalt into nitrat of ſilver as long as any precipitation takes place, and boiling the mixture; the white curdy matter thus obtained is to be mixed with three parts of good pearl-aſh, one part of waſhed whiting, and ſomewhat more than one part of common ſalt. The ſurface of the braſs being cleared from ſcratches is to be rubbed with a piece of old hat and rotten ſtone to remove any greaſe, and then is to be moiſtened with ſalt and water, a little of the compoſition being now rubbed on with the finger, the ſurface of the metal will preſently be covered with ſilver. Then waſh it well, rub it dry with ſoft rag, and as the coat of ſilver is extremely thin, cover it with tranſparent varniſh to preſerve it from tarniſh. This kind of ſilvering is very imperfect, and is only uſed for the faces of clocks, the ſcales of barometers, and ſimilar objects.

3. *Silvering by Silver in Subſtance.*

There are three ways of performing this. The firſt is by mixing together 20 grs. of ſilver precipitated by copper, 2 drachms of tartar, 2 drachms of common ſalt, and $\frac{1}{2}$ a drachm of alum; this compoſition being rubbed on a perfectly clean ſurface of copper or braſs, will cover it with a thin coating of ſilver, which may afterwards be poliſhed with a piece of ſoft leather.

A ſtill better way is that which is called French plating, which conſiſts in burniſhing down upon the ſurface of the copper ſucceſſive layers of leaf-ſilver to any required thickneſs. In this the ſilver has much more ſolidity than in any of the former, but the proceſs is tedious, and the junctures of the leaves of ſilver cannot always be entirely concealed.

The Engliſh method of plating (in thoſe works to which it is applicable) appears to be the beſt of all. It is thus performed: one of the ſurfaces of an ingot of copper is rendered quite ſmooth and clean, and is ſprinkled over with glaſs of borax; upon this is laid a plate of fine ſilver, about $\frac{1}{12}$ of the weight of the copper and the two are carefully bound together by wire; the maſs is now expoſed to a full red heat which melts the borax and cauſes the ſilver to adhere to the copper; the ingot is now paſſed through a rolling preſs, and formed into a plate; both the ſilver and copper extending uniformly during the whole proceſs, at the concluſion of which the two metals are inſeparably fixed to each other.

SINOPLE. See JASPER.

SIZE. See GELATIN.

SKIN. For the preparation of the ſkin of animals for the purpoſes of manufacture, ſee the article LEATHER.

SLAG. Is a technical term uſed among ſmelters and workers in minerals, to expreſs any hard vitreſcent generally coloured and opake maſs; produced by the fuſion of any ſtony or metallic mixture. It generally conſiſts of the gangue or matrix of the ore, together with any ſaline or earthy flux that may have been uſed. Thus the *ſlag* of iron founderies is for the moſt part compoſed of the earthy part of the ore, of the lime uſed as a flux, and the whole deeply coloured with a part of the oxyd of iron which has eſcaped reduction. A *ſlag* differs from a *ſcoria* in being more denſe and more compleatly vitrefied, whereas the ſcoria or droſs is lighter and porous. When the ſlag is very opake and heavy, it contains a conſiderable quantity of metallic oxyd ſo that in improved ſmelting works it is often worth while to work over again with freſh reducing matter the ſlags of former operations conducted leſs ſkilfully. In ſome parts the ſlag of founderies is broken into lumps, and uſed for mending roads, for which it makes an excellent material when a little worn down, being very hard, and impenetrable by water.

SLATE. See THONSCHIEFER.

SMALT. See COBALT.

SMARAGD. See EMERALD.

SMELTING, *Schmeltzung*, Germ. is the reduction of metallic ores and fuſion of metals in the large way.

SOAP. *Seife*, Germ. *Savon*, Fr.

A ſoap may perhaps be defined to be a chemical union of any oily with any ſaline matter whereby the oil acquires a ſolubility in menſtrua with which it naturally refuſes to unite.

In this extended ſenſe many compounds are called *ſaponaceous* or *ſoapy* which are natural or artificial mixtures of the ſaline and the oily or reſinous; thus bile is termed a ſaponaceous fluid becauſe it contains a natural reſin and an alkali in intimate union, and miſcible to any extent with water. Adipocire likewiſe is a ſaponaceous ſubſtance, being diffuſible in water, and to a certain degree ſoluble in it by means of the ammonia united to the oily matter. Milk on the other hand is not ſaponaceous, though it contains an oil diffuſed in a watery ſerum, as the intermede by which this is effected is (to all appearance) not ſaline, but albuminous and inſipid.

But the term *ſoap* is in common language reſtricted to that combination of oil with alkali which is extenſively uſed for domeſtic and manufacturing purpoſes.

The materials uſed in ſoap making are, oil of any kind, vegetable or animal, and fixed alkali, either ſoda or potaſh. Theſe (that is, oil and alkali,) enter into the compoſition of every ſoap, and beſides, lime is eſſential to give the alkali the requiſite degree of cauſticity: common ſalt is alſo employed in moſt of the potaſh-ſoaps, for a purpoſe which will be afterwards mentioned.

The general proceſs for ſoap-making is on the whole very ſimple, and conſiſts, firſt in making a cauſtic or partly cauſtic ley with the alkali and lime; next of boiling the ley with the oil till they are perfectly united into a ſmooth uniform ſoap; and laſtly of drying the ſoap till it is become of a proper conſiſtence for uſe. But though the general proceſs is ſimple, and ſucceſs to a certain degree may be inſured by any one who puts the proper ingredients together in the plaineſt manner, there are a conſiderable number of precautions and many minute attentions required to make the beſt and moſt perfect article with the greateſt economy. Moſt of theſe are only to be learnt by practical experience, but it will be proper in this place to enlarge upon the different ſteps and varieties of this very important manufacture.

The ſimpleſt, and on the whole the moſt beautiful ſoap, is the fine white ſoap prepared from olive oil and ſoda, extracted from the beſt barilla, which is manufactured very largely in the countries where the olive grows, eſpecially in the South of France, (for which Marſeilles is the moſt celebrated) in ſome parts of Italy, and in Tripoli, which laſt is often of excellent quality and cheap, and is largely imported into various parts of Europe. A ſimilar, but more expenſive ſoap is made of ſoda and oil of almonds, for medicinal purpoſes. What is called in this country *Windſor ſoap* is of this kind, with either of the above mentioned oils.

But the common ſoaps uſed in England are made, as to the oil, principally of tallow and any other candle or kitchen greaſe, and as to the alkali, of potaſh, pearlaſh, and other kinds of the vegetable alkali, with or without a mixture of barilla, according to the price of the latter; and on account of the peculiar uſe of common ſalt in moſt of them, the proceſs is ſomewhat more complicated. The ordinary *yellow* ſoap alſo differs from the *white*, in containing a portion of roſin, and ſometimes alſo is ſcented with palm oil.

We ſhall firſt deſcribe the method of making the white olive oil ſoap, which with ſome little variations is practiſed at Marſeilles, and other parts of France.[a] [b] [c]

To make about 1000 lbs. of this ſoap the materials requiſite are 500 lbs. of good barilla, 600 lbs. of olive oil, (of which the inferior ſorts are uſed, and anſwer full as well) and 100 lbs. of quicklime. The barilla being firſt broken down in a mill to a coarſe powder, and the lime ſlacked with a little water and ſifted, they are ſtirred together and put into a vat with a perforated bottom, and covered a few inches with water, to extract the alkali. In two or three days the ſtop-cock at the bottom of the vat is opened, and a clear, nearly cauſtic, ſtrong ley of ſoda is drawn off. It ſhould be ſo much concentrated that a freſh egg will ſwim in it, and is about of that ſpecific gravity that eleven drams of it in weight will only fill a bottle which would contain an ounce or eight drams of water. When all this ley is drawn off, the cock is turned, freſh water is poured on the materials, and after ſtanding for ſome hours the ley is drawn off as before. This ſecond ley is ſtill very alkaline, but much weaker than the firſt. A third ley is generally prepared in the ſame way, which is ſtill weaker. The materials, which are now exhauſted of their alkali and conſiſt of carbonat of lime with the impurities of the barilla, are uſed as manure.

The oil is then poured into the boiler (which is a large copper veſſel, ſet in brick work, and heated by a furnace under its bottom) and with it the third or weakeſt ley, and the fire is kindled and raiſed till the liquor begins to boil. The materials are conſtantly ſtirred to haſten the union between the oil and the alkali, and the reſt of the third and the ſecond leys are added gradually. As ſoon as the liquor in the boiler begins to get hot it turns milky, and after ſome hours boiling will be found to become more tenacious and thicker. Then a ſmall portion of the firſt or ſtrongeſt ley is thrown in, and this addition is continued at intervals during the boiling till the greater part of it is uſed, but ſome muſt be reſerved to finiſh the operation. The liquor becomes more and more tenacious, and the tough ſaponaceous part begins to ſeparate from the clear watery liquid below. This is a ſign that the proceſs is going on well, and the boiling is continued till the whole contents of the copper are viſibly ſeparated into two parts, the tenacious white ſoapy maſs above, and the clear liquor below. When this is compleat, ſometimes it is the cuſtom to ſtir in with poles a few pounds of common ſalt, which ſtill further promotes this ſeparation, and gives the ſoapy maſs a paſty or granular conſiſtence: but this addition (which is eſſential in the potaſh ſoaps) is not neceſſary in thoſe with ſoda, and may be omitted. The fire is then drawn, and the contents of the boiler allowed to remain at reſt for ſome hours that the ſoap may collect more compleatly, after which a cock is opened at the bottom of the boiler, and the clear liquor drawn off. This latter is coloured and is now no longer cauſtic, but as it ſtill contains ſome alkali, it is mixed with the weaker leys and freſh lime, and reſerved for future boilings. To the ſtiff ſoapy paſte left in the boiler a little water or weak ley is then added, and the fire lit again, and when it has become fluid the reſerved part of the firſt ley is added, and the whole brought to boiling. The ſoap being now nearly perfect, ſmall portions of it are taken out with a trowel and ſet to cool on a bit of ſlate, and by the degree of ſtiffneſs which it takes when cold the experienced workman judges when it is boiled enough. If it ſtill ſticks to the fingers and does not appear ſtiff enough, more ley muſt be added, and the boiling continued till it is brought to the proper ſtate. The fire is then again taken out and the clear liquor drawn off as before after remaining at reſt for a few hours. The fire is then again raiſed, and the ſoap is again melted with a little water to waſh out the adhering alkali, after which it is allowed to cool till it is fit to be taken out and *framed*. The frames are wooden troughs with a moveable bottom, into which the ſoap is poured while ſtill fluid, and allowed to remain for three or four days till it is ſtiff enough to be handled without ſinking in. The ſoap is then taken out and cut into long oblong ſlices with a braſs wire, and kept for ſome time in an airy room till it has become of the requiſite hardneſs, and is then fit for ſale. According to the valuable memoirs on this ſubject by Pelletier, Darcet, and Leſievre, above quoted, 3 lbs. of oil will make 5 lbs. of ſoap of the proper degree of dryneſs for uſe, but it continues to loſe weight by keeping, ſo that when quite dry the above quantity is reduced to little more than 4 lbs. On the other hand when kept damp or uſed too ſoon, more than twice this weight may be made of the ſame materials.

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[a] Memoires de Pelletier.

[b] Encycl. Arts and Metiers, article *Savon*.

[c] Beaumé Elemens de Pharmacie.

Such is the uſual way of making this kind of ſoap, which conſiſts of a gradual incorporation of the oil with the alkali by the aſſiſtance of heat, beginning with a weaker ley and concluding with the ſtronger. It is ſaid however that ſome of the Marſeilles manufacturers uſe the whole alkali at once, and ſucceed very well in this way; nor is it eaſy to ſay why this graduated ſtrength of alkali and theſe repeated interruptions of the proceſs during the coolings and ſettlings are required, and why it might not all be made economically by one continued boiling. Nevertheleſs, the interrupted method ſeems to be that which is by much the moſt commonly uſed, and probably experience would prove its utility in the large way.

It is not eſſential to employ heat in producing a good ſoap, for the union between the oil and alkali will be perfect by a ſufficient length of time of digeſtion if the ley be ſtrong enough. Thus a very pure ſoap is ſometimes made for medicinal purpoſes in the following way:[d] mix in a marble mortar or any veſſel not metallic, any quantity of olive oil with half its weight of a ſtrong ley of cauſtic ſoda. The oil ſhould be previouſly melted in caſe it has become clotted by age. Stir them well together and they will immediately unite into a thick white maſs, and continue the ſtirring for ſome minutes ſeveral times a day for about a week, or till the ſoap is ſtiff enough to be put into wooden frames in the uſual way. Let it remain in the frames for three or four days till it has conſiderably hardened, and then cut it in ſlices and expoſe it to a free current of air in a dry room till it is compleat. This ſoap has at firſt a very ſtrong lixivial ſmell, and a violently acrid taſte, both of which go off by expoſure to the air, but it takes nearly a month before the taſte is mild or merely ſaponaceous.

Before we deſcribe the manufacture of the other kinds of ſoap we may give in a few words the reſults of a ſeries of valuable, and apparently accurate, comparative experiments on the ſoaps made with ſoda and a variety of oily ſubſtances, which were undertaken by Pelletier and his colleagues. The quantity of the oily ſubſtance in each inſtance was 3 lbs. and the method purſued was nearly that which has been deſcribed as followed in the large way.

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[d] Beaumé.

Olive Oil. 3 lbs. (avoirdupois) of this oil produced 5 lbs. of pure white ſoap in that ſtate of dryneſs as to be ſit for ſale. After keeping for two months it loſt an ounce more in weight, and was then quite dry, hard, and of an agreeable ſmell.

Oil of Almonds. 3 lbs. of this oil gave an excellent ſoap in every reſpect equal to the former, but after two months weighing only 4½ lbs.

Suet. The animal fats are much leſs uſed in France for ſoap-making than in this country, but the ſoap which they give is in every reſpect as good as that from olive oil. The precaution uſed in oil ſoap-making of employing the weaker ley at firſt, and gradually proceeding to the ſtronger, was not found neceſſary in this caſe. 3 lbs. of ſuet gave 5 lbs. of perfectly hard ſoap after keeping for three months and a half in a dry place.

Lard. 3 lbs. of lard gave 4 lbs. 14 oz. of dry hard ſoap after keeping for three months. In this and the former experiment the ſpent ley which ſeparated from the ſoap, contained a quantity of animal gelatine.

Rancid Butter. A quantity of ſtale ſalt butter was boiled with water to extract the ſalt, after which 3 lbs. of it were weighed out and treated with ſoda in the uſual manner. From the above quantity a white ſoap was obtained with eaſe, which the day after it was made weighed 11 lbs. and ſtill retained ſome of the bad ſmell of the butter, and on keeping for two months it ſtill weighed 7 lbs.

Horſe Oil. A good deal of greaſe is prepared near Paris from horſe fleſh, by boiling. Of this, 3 lbs. gave 5 lbs. of good hard ſoap without any unpleaſant ſmell, after keeping for two months.

Coleſeed Oil. Coleſeed, hempſeed, linſeed, rape, and many other common vegetable oils have a ſtrong unpleaſant ſmell and taſte, ſo as not to be uſed in food, but they are employed largely in the ſtate of oil for ſeveral purpoſes of manufacture. In general they are not much uſed for the *hard* ſoaps with ſoda, but a good deal of ſoft ſoap is made of them in Flanders and Holland, with pearl-aſhes, as will be preſently mentioned. In the above experiments they gave the following reſults.

3 lbs. of coleſeed oil treated as above with ſoda gave on coming out of the frame, only 5 lbs. of ſoap, which was yellowiſh grey, and ſtill ſmelled ſtrongly of the oil. On keeping for three months it was reduced to 3 lbs. 12 oz. and was tolerably hard, but by no means equal in this reſpect to olive oil, kept the ſame length of time.

Rape Oil. 3 lbs. of this oil gave alſo a yellowiſh grey ſoap, which after keeping for three months gave 4½ lbs. of a good ſoap, ſufficiently hard.

Beech-maſt Oil. 3 lbs. of this oil gave a grey ſtrong ſmelling ſoap, which after three months, weighed 4 lbs. 10 oz. and was ſtill paſty, and ſtuck to the fingers. This oil therefore can only be uſed in mixture with others that give a harder ſoap.

Hemp-ſeed Oil. This is one of the moſt valued oils for the ſoft ſoaps, but will not anſwer for the hard. 3 lbs. gave after due boiling, a green ſoft ſaponaceous maſs, which became paſty on any addition of water. After two months it weighed 4½ lbs. and hardened a little, but not ſufficiently to be uſed in common waſhing.

Linſeed Oil. 3 lbs. of this gave 5 lbs. of ſoap on coming out of the frames, which was greaſy, paſty, and adheſive, with a very ſtrong ſmell, and ſoftened ſpeedily on any addition of water. In two months it loſt half a pound of its weight, but remained paſty and adheſive.

Whale Oil. This, and other kinds of fiſh oil, unites ſufficiently well with ſoda, and forms a deep red-brown ſoap of tolerably hard conſiſtence; but this ſoap has the inconveniences of long retaining the offenſive ſmell of the oil, and being too readily ſoftened by water, which unfit it for domeſtic purpoſes, though it may be uſed in bleacheries, &c. where the ſmell may be diſſipated by long expoſure to air. 3 lbs. of this oil gave 4½ lbs. of ſoap, after keeping for two months. Ling and ſeal oil ſoap have nearly the ſame properties and inconveniences.

All the above experiments were repeated with the cryſtallized carbonat of ſoda inſtead of the barilla of commerce, which was employed in the firſt ſet of experiments, and the reſpective reſults ſo nearly agreed with the former that a particular enumeration of them is needleſs. In theſe latter 3 lbs. of carbonat of ſoda, rendered cauſtic by 1 lb. of lime, were uſed for 3 lbs. of the oil; but in manufacturing in the large way the experimenters conceive that 80 parts of the alkali would be ſufficient for 100 of the oil.

The olive oil, Marſeilles, and other ſoaps are ſometimes artificially *marbled* or ſtreaked throughout their whole ſubſtance with red or blue veins. This ſoap is harder than the white ſoap of the ſame materials becauſe it requires to be dried to a greater degree to take the marbling. This is performed by adding to the ſoap, as ſoon as it is compleatly made and ſeparated from the ſpent ley, a freſh quantity of ley and immediately after a ſolution of ſulphat of iron. A decompoſition between the two takes place, and a black oxyd of iron is ſeparated which is entangled within the liquid ſoap. The boiler is then cooled, and the ley which ſettles is drawn off, after which the ſoap is again melted. A workman then ſtands over the boiler and ſtirs the ſoap with a wooden inſtrument whilſt another throws in at intervals a quantity of colocothar or brown red oxyd of iron, ground up with water into an uniform liquid. This difuſes both the oxyds through the ſoap, which is then cooled and framed. There appears to be ſome manual dexterity required in ſtirring theſe ingredients together, ſo as to diffuſe the marbling ſufficiently through the maſs without mixing it compleatly.

All the ſoaps which we have hitherto mentioned are made with ſoda in one form or other, which alkali appears too to have been of the moſt antient uſe in ſoap-making; but there is another ſpecies in which the ſole alkali is the vegetable in the form of pearl-aſh, pot-aſhes, wood-aſhes, and the like, and in which no common ſalt is employed. Theſe potaſh ſoaps differ eſſentially from the others in remaining always ſoft and paſty however long they are kept. On this account they are not employed in common domeſtic uſes, but are chiefly uſed in ſcouring wool and other purpoſes of manufacture. However as they are perfect ſoaps, and entirely ſoluble in water, they may be partially employed in rendering water ſoapy for any purpoſe of cleanſing.

Soft ſoap is always coloured, generally of a brown or deep green, which however only depends on the nature of the oil uſed, for with olive oil it is white. It is much ſtronger and more acrid than the hard ſoaps, but in other reſpects it has the ſame chemical properties. The conſiſtence ſhould be that of a tenacious paſte or glue even in the hotteſt ſummer, and it ſhould melt readily in water forming a white and light froth. The mode of manufacture of this ſoap differs in this eſſential particular from the other, that no ſeparation takes place between the ſoap and the ſpent ley as in the ſoda ſoaps, but the whole contents of the boiler after ſufficient boiling and evaporation are converted into ſoap; neither is there any of the proceſs of framing and drying. A good deal of practical skill alſo (more than can be learnt from books) ſeems to be required in producing the proper union between the oil and alkali, and the proceſs appears liable to ſudden and often unaccountable failures, from the refuſal of the materials to unite with ſufficient intimacy, or from their diſunion after having already combined.

The manufacture of the beſt ſoft ſoap in Flanders and Picardy is thus deſcribed.[e] The oils uſed in theſe works are linſeed, hemp, poppy, coleſeed, and rape. Of theſe the two laſt are the cheapeſt and leaſt eſteemed. Fiſh oil alſo anſwers perfectly well, but the offenſive ſmell of the ſoap made from it is ſo permanent that its uſe is forbidden. The alkali is generally Dantzic, or Ruſſian pearl-aſh which is mixed with lime and lixiviated, till a ley ſtrong enough to bear an egg is obtained, and only one degree of ſtrength is uſed except reſerving a weaker ley for occaſional dilution of the ingredients. The boilers are the ſame as for hard ſoap, and ſhould not be filled more than half-full, on account of the great riſing of the contents whilſt they are incorporating. The proportions of the materials are on an average about 30 parts of oil to 40 of ſtrong ley, which yield about 65 parts of ſoap. The management of the boiling and gradual addition of the ley to the oil require conſiderable attention, and if it has ſucceeded properly, the oil and alkali unite into an uniform gluey ſaponaceous maſs, after which the boiling is continued till enough of the watery part has evaporated to leave the remainder of the proper conſiſtence when cold, which is known to be the caſe when a ſample taken out and cooled does not ſtick to the fingers and draw out in threads, but remains brown, ſomewhat ſtiff, and granulated. The boiler is then entirely emptied, and the ſoap is barrelled for ſale.

When the boiling has not been continued long enough, the ſoap is apt to ferment, and ſpoil by keeping.

Soap is manufactured in this country principally from tallow or any other fat; and the alkali employed is either barilla or pearl-aſh, or a mixture of the two, according to the price and practice of the manufacturer. But as potaſh alone will not make a ſtiff ſoap, recourſe is had to the action of common ſalt, which, when added after the potaſh and oil are united, produces a ſeparation of the compound from the water incorporated with it, hardens it, and renders it equal to the ſoda ſoaps.

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[e] Encycl. Meth.

The following is the uſual method of making the common white and yellow ſoap uſed in domeſtic purpoſes.[f]

White hard ſoap is generally made with three ſeparate charges of ley. The potaſh (ſuppoſing this to be the alkali) is previouſly diſſolved with water in a ſmall boiler with a little fire, and the ſolution is poured over a vat containing common wood-aſhes mixed with lime, which makes the firſt and ſtrongeſt ley.

As ſoon as this has run off the aſhes are turned, more lime is added, and water is pumped on, which forms the ſecond or weak ley. The large boiler is then charged with the tallow, and about two-thirds of the ſtrong ley being added, a moderate fire is kept up to incorporate the materials, which is known by their running into a ſtiff glue. If this does not take place in about 7 hours (with 29 cwt. of tallow in the boiler) more alkali muſt be added. The tallow is then *killed* or ſaturated, and the fire is drawn and the materials allowed to remain at reſt for a ſhort time. Common ſalt is then thrown in, and ſtirred up with long poles till it is thoroughly incorporated, and till the matter changes from a dark coloured glue to a thin ſoapy ſubſtance. A briſk fire is then made, and the materials boiled for a few minutes, when the fire is again drawn, and the materials in the boiler allowed to ſettle for an hour and a half, during which the ſpent lees ſink to the bottom of the boiler, and are pumped off. The ſecond operation begins with raiſing the fire and adding to the ſoapy maſs the weak ley, which is to be managed the ſame as at firſt and again brings it to the ſtate of a glue, which a very little ſalt will reſtore to the ſaponaceous ſtate, and after boiling and cooling the ſecond lees are pumped off. In the third operation the third part of the ſtrong ley which was reſerved is added, which as before, changes the maſs to a thick glue, that muſt be grained with ſalt as before.

The contents are then boiled ſtrongly for three hours, more or leſs, till by taking ſamples occaſionally with a trowel, the ſoap feels ſufficiently hard and dry to the touch, and the ley will be ſeen to run quite clear from the ſoap on the trowel, leaving this latter in round lumps. The boil of ſoap is then finiſhed by pumping off the ſpent ley, and ſcraping off a quantity of light froth from the top of the ſoap. The ſoap is then fit for framing, which is a perfectly ſimple proceſs, and has already been deſcribed.

With regard to the proportion of ingredients, it is reckoned that 16 buſhels of good wood-aſhes are equal in alkali to 1 cwt. of the beſt pearl-aſh, and that this latter quantity will ſaturate 2 cwt. of tallow, and produce 3 cwt. 1 qr. of ſoap, ſo that 12 parts of tallow will make 20 of ſoap. Alſo, 12 buſhels of wood-aſhes are reckoned equal to 1 cwt. of barilla, and the latter quantity will ſaturate 1½ cwt. of tallow. A boil of 29 cwt. of tallow with 10 cwt. of barilla, and 5 cwt. of pearlaſh (as theſe alkalies are often mixed) requires about 8 cwt. of common ſalt.

Common ſalt appears to have two diſtinct uſes in ſoap-making; one is, that of promoting the *graining* or ſeparation of the ſoap from the ſpent ley, which it does probably ſimply by abſtracting the watery part. In this way it is of as much uſe in the ſoda as the potaſh ſoaps, and in each it conſiderably haſtens the proceſs; but it is by no means eſſential, and on account of its high price appears to be ſeldom uſed, where barilla or ſoda is the ſole alkali. But where a large portion of the alkali is potaſh, the ſoap would remain in the ſtate of a ſoft paſty maſs (as we have already ſeen) and actually does ſo, till the addition of common ſalt, which then brings the ſoap to the ſame ſtate as the ſoda ſoaps.

It is therefore probable, as ſuggeſted by Pelletier, that in theſe caſes a double decompoſition takes place between the oil and potaſh on the one hand, and the muriatic acid and ſoda on the other, and that the products of this change of principles are a ſoap with oil and ſoda, and muriat of potaſh in the mother liquor.

To illuſtrate this, the ſame ingenious chemiſt made the following experiments: 3 lbs. of olive oil were boiled with a potaſh ley following the ſame preciſe proceſs as that already deſcribed for the ſoda ſoap with this oil, and the reſult was a ſoft ſoap of the conſiſtence of butter weighing 8 lbs. On the other hand 6 lbs. of common ſalt were diſſolved in ſufficient water and this ſolution was added by degrees to the ſoft ſoap again made fluid by boiling. After keeping up the fire for two hours, the whole was cooled, and a very ſolid ſoap collected at the ſurface which was again melted with water to waſh out the adhering ſalt, and then framed in the uſual manner. After two months it weighed only 5 lbs. and was hard, white, and of an agreeable ſmell. The ſame experiment was repeated with ſimilar reſults, employing the ſulphat of ſoda inſtead of the muriat.

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[f] Original Communication.

It is rather ſingular however that this accurate chemiſt did not (as appears) examine the ſpent ley to diſcover in it the potaſh, which he ſuppoſes to be diſplaced from the firſt ſoap, but the experiment may eaſily be made. A ſimilar trial was alſo made with 3 lbs. of ſuet and potaſh, which after the addition of common ſalt, gave a hard ſoap, weighing, in two months time, about 6 lbs.

The common yellow ſoaps are made in this country with tallow and barilla, to which, after ſaponification, is added a quantity of roſin, and ſometimes a very little palm-oil.

The tallow is firſt compleatly ſaturated with the ley till the clear liquor, which is drawn off after due boiling, is nearly as alkaline as when added, after which the roſin is melted in, and thoroughly incorporated.

The following gives a good yellow ſoap, viz. 25 *cwt.* of tallow, $4\frac{1}{2}$ *cwt.* of oil, 7 *cwt.* of roſin, 18 *cwt.* of barilla; and 10 *cwt.* of black aſhes (or waſte ley evaporated and calcined) and $\frac{1}{2}$ *cwt.* of palm oil. The produce is about 64 *cwt.* of yellow ſoap.

In the preparation of all the hard ſoaps, a ſeparation of the ſoap from the watery ſaline ſolution always takes place towards the end of the proceſs, and it is this ſeparation which enables the artiſt to collect and dry the ſoap. But the queſtion occurs, how this ſeparation takes place; for the liquor from which it ſeparates is ſtill alkaline, often very ſtrongly ſo, and if the ſame ſoap, after it is fully prepared and dry, is rediſſolved in an alkaline liquor, it will mix with it uniformly into a white ſaponaceous fluid.

Pelletier[g] has endeavoured to ſhew by ſome ingenious reaſoning, and by experiment, that carbonic acid is an eſſential ingredient in the hard ſoaps, and from the fact that cauſtic alkali will decompoſe alcohol, and become more or leſs carbonated by the carbonic acid, which is thereby generated, (*for which ſee the article Potaſh*) he infers that during ſoap-boiling, the pure alkali and oil firſt unite into a ſaponaceous maſs, during which he ſuppoſes that part of the oil is decompoſed, and furniſhes carbonic acid, which then unites with the ſaponaceous fluid, and forms with it a triple compound of oil, alkali, and carbonic acid, which conſtitutes hard ſoap. In the preparation of ſoap without heat he further ſuppoſes that part, if not all, of the carbonic acid may be furniſhed by the atmoſphere, which will account for the length of time required before the ſoap made in this way will harden and ſeparate from the ley.

He alſo gives the following experiments: Four ounces of cauſtic ſoda ley were mixed, without heat, with eight ounces of oil of almonds, and with frequent ſtirring, but it was not till after many days, that the ſoap began to harden. On the other hand 4 oz. of the ſame ley, 8 oz. of oil, and 4 oz. of water ſlightly carbonated, were mixed together; the compound ſoon began to ſtiffen, in a quarter of an hour it had acquired the conſiſtence of an ointment, and in 12 hours it was hard enough for uſe. Alſo 4 oz. of the ley were mixed with 8 oz. of the oil previouſly aerated with carbonic acid, and here too the ſoap became ſolid much ſooner than in the firſt inſtance, though later than in the ſecond experiment. If it be objected to this opinion of the neceſſity of carbonic acid to hard ſoap, that a carbonated alkali will not make ſoap, the author brings the analogy of calcareous cements or mortar; for ſand and carbonat of lime will not cohere into a mortar, but when the combination between ſand and quicklime is once made, the induration is much haſtened by adding carbonated water.

To this ingenious hypotheſis however we may object that there is no proof brought that ſoap actually contains carbonic acid, and the contrary may be inferred from its not effervеſcing with a ſtronger acid, ſo that the analogy with calcareous mortar is defective in the moſt eſſential point. To aſcertain the preciſe action of the alkali on oils, it will alſo be neceſſary to examine the ſpent ley, which appears to contain what alkali remains in it, in a much more carbonated ſtate than the freſh ley; ſo that inſtead of ſuppoſing that the ſoap contains carbonic acid, we might with as much probability conjecture that in the proceſs a part of the alkali becomes to a certain degree carbonated at the expence of the other, and that it is the latter portion, or the pure alkali, which unites with the oil into ſoap, whilſt the former ſeparates from it through the aſſiſtance of its carbonic acid. This would perhaps explain equally well the action of carbonated water in haſtening the ſeparation of the ſoap from the remaining ley, but much remains to be done by the ſcientific chemiſt in illuſtrating this very important manufacture.

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[g] Memoirs de Pelletier. tom. I.

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The chemical properties of every alkaline ſoap are the following: when wetted, it ſwells, ſoftens, and abſorbs a large quantity of water, and if more is added it diſſolves therein, making a ſolution which at firſt is ſomewhat opaleſcent or grey but by repoſe becomes clear. Soap-water when agitated forms a large quantity of white frothy bubbles which remain for a conſiderable time before they burſt, and may be inflated to a vaſt bulk, as is ſeen in the common amuſement of blowing ſoap-bubbles. Hot water diſſolves ſoap more rapidly and in larger proportion than cold. Soap will keep in a dry place for a great length of time unaltered, but when damp, a part of the alkali gradually ſeparates and appears on the ſurface as a ſaline efflorescence of carbonat of ſoda. Diſtilled *per ſe*, it yields moſt of its oil tolerably pure, after which the reſidue blackens, exhales a fetid ſmell and black ſmoke, and finally the alkali alone is left in a carbonated ſtate.

Soap is alſo ſoluble in alcohol.

The ſolution of ſoap is decompoſed by all the acids, which *curdle* it, or ſeparate the oil in the form of white lumps. An exceſs of acid rediſſolves the curd, and the oil is transferred to the acid, but on boiling this ſolution, the oil ſeparates entirely, and riſes to the ſurface. The ſolution is alſo curdled by lime, barytic or ſtrontian water, and in this caſe the curd conſiſts of the oil united with the earth and concreted by this union. All the ſoluble ſalts of theſe and the other earthy baſes equally decompoſe ſoap-water, and form a curdy precipitate, which is the reaſon why *hard* water, that always contains ſulphat of lime, and often other earthy ſalts, immediately curdles ſoap inſtead of forming an uniform ſolution. The metallic ſalts alſo produce the ſame effect, and a combination of the oil and metallic oxyd is produced.

Theſe ſeveral decompoſitions have been examined by Berthollet.[h] The oleo-calcareous curdy precipitate formed by adding a ſolution of ſoap to lime-water, is not altered by cauſtic alkali, which proves that oil has a ſtronger affinity with lime than with alkali, but if a carbonated alkali is uſed, the oleo-calcareous compound is decompoſed, the lime becomes carbonated, and ſeparates, and the alkali goes to the oil. This alſo affords another preſumptive argument againſt the exiſtence of carbonic acid in common ſoap. Ammonia has no more effect on the oleo-calcareous compound than the fixed alkalies have, but if carbonated ammonia is digeſted with it, carbonated lime is produced, and the ammonia and oil unite compleatly. If this latter ſolution is evaporated, a ſoap remains, which is more pungent than common ſoap, is largely ſoluble in alcohol, but imperfectly ſo in water. A ſimilar ammoniacal ſoap is formed, and ſeparates immediately in white curds by adding a ſolution of common ſoap to muriated ammonia.

It has been mentioned that all the earthy ſalts decompoſe ſoap. With Epſom ſalt an oleo-magneſian precipitate is formed which is unctuous, dries with difficulty, is inſoluble in boiling water, but eaſily diſſolves in alcohol or expreſſed oil. In a moderate heat it melts into a yellowiſh tranſparent maſs.

An oleo-aluminous compound is formed by adding alum to a ſolution of common ſoap. This forms a ſoft flexible maſs, which preſerves its ſuppleneſs in drying, and is ſcarcely ſoluble in water, alcohol, or oil.

The ſame excellent chemiſt examined ſeveral of the oleo-metallic compounds formed by adding a ſolution of ſoap to the metallic ſolutions. With corroſive ſublimate a quantity of ſmall coagula were produced, and more readily with nitrat of mercury. This combination is viſcid, dries with difficulty, diſſolves in oil and alcohol. It becomes of a deep ſlate colour by expoſure to the air, and readily ſoftens by heat.

Sulphat of zinc decompoſed by ſoap gave a yellowiſh white compound; the nitro-muriat one of a dull leaden colour.

Nitro-muriat of tin gave a white compound, which differed from all the others in not being fuſible by heat, owing to the quantity of metallic oxyd which it contained.

The ſalts of iron give a reddiſh-brown oily compound, very tenacious and eaſily fuſible. It is readily ſoluble in oil and oil of turpentine.

Sulphat of copper gives a copious green maſs reſinous in appearance, which becomes brittle on drying. Digeſted in alcohol its colour deepens, but it does not diſſolve except with heat. Ether much improves the colour and diſſolves a portion. This compound is readily and largely ſoluble in oils to which it gives a green colour.

Acetite of lead gives a white tenacious maſs, very adheſive when heated, and reſembling diachylon, which is a direct combination of oil and litharge.

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[h] Mem. de l'Acad. for 1780.

The author adds a few general remarks on theſe combinations. The expreſſed oils did not appear to diſſolve the compound of oil with lime or alumine. Alcohol diſſolves ſome of the oleo-metallic compounds without heat, others require heating; but in all caſes it diſſolves leſs of them than oil of turpentine does.

Some of theſe were calcined, to determine the quantity of earth or metallic oxyd left after the oil was burnt off, whence ſome idea may be formed of the proportions of ingredients in theſe compounds, taking into account however, that the calcination might carbonate ſome of the earths, but not all, and that the exact ſtate of oxygenation of the metals is not aſcertained. Half an ounce, Fr. (288 grs.) of the compound with magneſia left 32 grs. which did not effervesce: the compound with lime left 36 grs. which effervesced; with clay, 28 grs; with iron, 48 grs; with copper, 33 grs; with zinc, 42; with mangane ſe, 40; with ſilver, 30 grs. in the metallic ſtate; and with tin, as much as 79 grs. of the reduced metal. Whenever theſe combinations are to be made, the ſolutions ſhould be in a ſaturated ſtate.

Ammoniacal Soap.

A white ſaponaceous compound is readily made by ſhaking any oil with liquid ammonia, and this combination is much uſed medicinally as a ſtimulating application; but the union between the two is much weaker than between the fixed alkalies and oils, ſo that this compound will not harden, and by keeping for a time the ingredients partly ſeparate. A more intimate union between them is made by adding muriated ammonia to common ſoap, as has been already mentioned.

Eſſential-Oil Soaps. Starkey's Soap.

The combination of the eſſential oils with the fixed alkalies is much more difficult than that of the expreſſed oils and fats, and much leſs perfect, ſo that a ſeparation is liable to take place whatever pains be taken in the mixture. This kind of ſoap was firſt introduced by an alchemiſt of the name of *Starkey*, whence it has taken its name. Starkey's proceſs was tedious and uncertain. It conſiſted in putting in a veſſel ſome dry carbonat of potaſh with oil of turpentine and ſhaking the mixture daily for ſix months, during which time part of the oil combines with the alkali into a ſaponaceous maſs, and the remainder floats above it unaltered. Beaumè has taken a good deal of pains to find out the beſt method of making this mixture. His method is the following.[1] Put in a marble mortar, or on a porphyry ſtone, any quantity of dry carbonat of potaſh, add to it gradually twice or thrice its weight of oil of turpentine, and rub them together till the mixture has the conſiſtence of a ſoft extract; then put it into a glaſs cucurbit and ſet it (at reſt) in a damp place, during which the mixture abſorbs much moiſture from the air, and reſolves itſelf into three portions, the loweſt of which is a watery ſolution of the alkali, the middle is the ſoap required, and the upper portion is ſome uncombined oil of turpentine, generally yellow or amber-coloured. Pour the whole on a ſtrainer of double cloth, and the ſoap alone remains on the ſtrainer, which after draining for ſome days muſt be again rubbed in a mortar, and is then compleat. The alkaline liquor that runs through the filter is ſomewhat impregnated with the oil. Other recipes have been given for this ſoap, the preparation of which has engaged more attention, perhaps, than it merits as a medicine, and which need not be repeated in this place. This ſoap has an acrid alkaline taſte, and is very apt to deliquiate on expoſure to air.

It does not appear however that the ſolid cauſtic alkalies have ever been uſed for this purpoſe, ſo that experiments are ſtill wanting to aſcertain the preciſe action of the alkalies on the eſſential oils.

Acid Soaps.

The combination of acids with oils into ſoluble ſaponaceous ſubſtances, has already been noticed under the article OIL.

SOAP, *Starkey's*. See the preceding article.

SOAP-LEES. *Lixivium ſaponarium.*

This term has been not unfrequently uſed both by chemical writers, and alſo familiarly, to ſignify the *ley* or alkaline lixivium uſed by ſoap-boilers. In this country therefore it means a very ſtrong ſolution of potaſh, nearly, if not entirely cauſtic; but in the countries where ſoda is chiefly uſed by the ſoap makers, it ſignifies a ley of cauſtic ſoda. It is therefore an incorrect term, and is nearly diſuſed.

The term *ſoap-lees* is alſo employed technically by ſome to ſignify the *ſpent ley* which is pumped out of the ſoap ciſtern after the ſoap has ſeparated, and being generally more or leſs alkaline, it is never thrown away, but is ſometimes uſed again in the ſtate in which it is obtained, and at other times is evaporated and the reſidue calcined to extract the alkali.

SODA. Mineral fixed Alkali. *Soude*, Fr. *Mineraliſche gewachſalkali*, Germ.

This alkali is obtained pure from the native or unmanufactured Carbonat of Soda by preciſely the ſame methods which have been already amply detailed in the article Potash, to which we refer our readers. In its general properties it ſo cloſely reſembles potaſh that it is with the utmoſt difficulty that the two alkalies when in a pure uncombined ſtate, are diſtinguiſhed from each other. To avoid uſeleſs repetition therefore, we ſhall only mention here thoſe circumſtances in which ſoda differs from potaſh. The affinity of ſoda for water is much inferior to that which potaſh exhibits for the ſame ſubſtance, hence when ſolid cauſtic ſoda is expoſed to the air it preſently moulders to a moiſt paſte, but as ſoon as it has abſorbed carbonic acid enough to form the ſub-carbonat of ſoda, it parts again with its water and effloreſces to a white powder. Potaſh on the other hand, entirely deliquiates, and continues fluid till quite ſaturated with carbonic acid. The ſpecific gravity of ſoda according to Haſſenfratz is =1.33, whereas that of potaſh amounts to 1.70. Soda combines with ſilex and other vitrifiable ingredients into a glaſs in the ſame manner as potaſh does, but the glaſs prepared with the latter is harder than when the former is made uſe of. On the other hand the ſoaps produced by combining ſoda with oil or tallow are hard and ſolid, while thoſe made with potaſh are ſoft and gelatinous. The two alkalies are ſtill more diſtinguiſhable when united to the different acids, producing compound ſalts, and a conſiderably ſmaller proportion of ſoda than of potaſh will ſaturate a given quantity of acid. The ſalts with a baſe of ſoda are for the moſt part conſiderably more ſoluble than the correſponding ones with a baſe of potaſh, and in the force of its chemical affinity ſoda appears to be ſomewhat inferior to potaſh, this however is no doubt increaſed by the ſuperior ſolubility of its ſalts.

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[1] Elemens de Pharmacie.

Soda is applied in general to the ſame uſe as potaſh, and the preference given to either over the other is often determined merely by their relative commercial value. In the preparation of hard ſoap and the ſofter kinds of glaſs there is however an intrinſic ground of preference.

SOLDER.

The art of ſoldering is that of joining together two or more pieces of metal by means of a metallic cement: hence it is abſolutely requiſite that the ſolder employed ſhould have the two following qualities, viz. that of being fuſible at a lower heat than the metals which it is intended to cement, and of adhering with conſiderable firmneſs to their ſurfaces. The ſolder for gold is compoſed of fine gold with $\frac{1}{4}$ or $\frac{1}{2}$ its weight of fine ſilver, mixed together accurately by fuſion, and afterwards beat out into leaves ſomewhat thinner than card paper, and rendered as ſoft as poſſible by annealing. It is made uſe of in the following manner. A piece of ſolder of the proper ſize and ſhape being cut off, is laid on the part to be cemented and ſprinkled over with pulverized borax; the flame from a blowpipe is then applied, and the borax and ſolder both enter into fuſion, the latter incorporating with and adhering firmly to the gold: when the juncture is compleat the piece is allowed to cool, and the borax is removed by boiling water, or what is ſtill better a little dilute ſulphuric or muriatic acid. The ſolder will however appear conſiderably paler than the other part, both on account of the ſilver with which it is alloyed, and of the borax, which always lowers the colour of gold: this defect may be remedied by melting on the ſurface of the ſolder a mixture of two parts of nitre and one of burnt alum and afterwards waſhing it off with a ſoft bruſh and hot water, by which the natural colour of the gold will be reſtored and even heightened.

For ſilver there are two kinds of ſolder employed, the hard and the ſoft. The former is compoſed of equal parts of ſilver and fine braſs; and the latter is prepared by fuſing the hard ſolder with $\frac{1}{16}$ of its weight of pure zinc. The mode of applying it is the ſame as already directed for gold ſolder.

For copper, braſs, and the hard alloys of copper the beſt hard ſolder is compoſed of braſs and zinc in the proportion of from 8 to 16 of the former to one of the latter, according to the required hardneſs. The ſoft ſolder is compoſed of 3 parts of zinc and one of lead, and is applied by means of a common ſoldering iron heated red hot.

The ſolder for tin, pewter, and lead, (or the plumber's ſolder) is of two kinds: the leaſt fuſible is compoſed of equal parts of tin and lead; the more fuſible contains beſides, biſmuth in various proportions. A very good ſoft ſolder is prepared by melting together 16 parts of tin, 8 of lead, and 4 of biſmuth.

For delicate works in cut ſteel the beſt ſolder is gold with a high alloy of copper. For larger works in iron and ſteel copper is made uſe of, or an alloy compoſed of equal parts of tin and iron.

SOLUBLE TARTAR, or *Tartrite of Potaſh.* See Tartareous Acid.

SOLUTION. *Auflöſung*. Germ.

Solution is the perfect chemical union of a ſolid or fluid with any other fluid, in which the compound remains in a liquid ſtate, and perfectly homogenous in all its parts. It generally is applied to the *melting down* of a ſolid in a fluid (ſalt in water for example) but applies with equal propriety to the chemical union of two diſſimilar fluids, as where an eſſential oil is diſſolved in alcohol.

Solution is one of the great operations in chemiſtry, and almoſt every ſubſtance in nature is capable of it. The antient idea of ſolution does not imply chemical affinity, and the ſubſtance diſſolved was ſuppoſed to be as it were paſſive in the operation, ſo that in this point of view, ſolution was little elſe than *tranſparent diffuſion*. But more accurate ideas of chemical action have ſhewn that ſolution takes place from true chemical affinity operating between the *ſolvent* and the *ſolvend*, in which each ſubſtance equally participates. For a ſolid to be diſſolved in a fluid it is neceſſary that the force of affinity between the two ſhould be ſufficient to overcome the force of coheſion between the particles of the ſolid, and hence it is that heat ſo much aſſiſts ſolution by leſſening the force of coheſion between all particles of matter.

It generally happens in all caſes of ſolution at a common temperature that the mixture in the act of ſolution becomes either warmer or colder than the ingredients were before mixture. This ariſes from an evolution or abſorption of free caloric, owing to the mixture having a leſs or a greater capacity for caloric than the mean capacity of the two ſubſtances taken ſeparately. This has been more fully explained under the article *Caloric*.

It happens alſo in by far the greater number of caſes of ſolution that the mixture has a greater ſpecific gravity than the mean gravity of the ingredients, relatively to their reſpective quantities. Hence they occupy leſs ſpace than before, as may readily be ſeen by putting into a bottle any ſoluble ſalt (ſulphat of ſoda for example) and filling it brim-full of water, and after the ſolution is effected, the liquor will have ſunk a certain way below the firſt level without any loſs of the ingredients.

The whole ſubject of ſolution is intimately connected with that of chemical *affinity* to which we ſhall refer the reader.

SOOT.

Chimney ſoot is a compound of black carbonaceous matter with a conſiderable quantity of carbonated ammonia and probably ſome other ammoniacal ſalts, and hence it gives a ſtrong pungent ſmell of this alkali when rubbed with quicklime. Carbonated ammonia is extracted from it in the large way in ſeveral manufactories of this ſalt.

SORREL, *Salt of*, is the native ſuper-oxalat of potaſh contained in the juice of this plant. See Oxalic Acid.

SPANISH WHITE.

The ſubſtance originally called by this name, is the white of oxyd or magiſtery of biſmuth, the name is often however applied to waſhed chalk or *whiting*.

SPAR. *Spath*. Germ.

The term ſpar, in its moſt comprehenſive ſenſe appears to include almoſt all the earthy cryſtallized minerals that are met with in metallic veins; but by mineralogiſts it is applied to thoſe minerals whether earthy or metallic, which are cryſtallized and have a viſible foliated texture. Thus we ſay calcareous ſpar, fluor ſpar, heavy ſpar, felſpar, lead ſpar, ſpathoſe iron, &c. but not quartz ſpar. It is not however every foliated cryſtal which is called a ſpar, for neither mica nor hornblende bear this appellation. The adjective ſpathoſe or ſparry, means compoſed of *cryſtalline* plates, in oppoſition to foliated or ſlaty, which only imply compoſed of plates, without any reference to cryſtallization.

SPARGELSTEIN. See Apatit.

SPECKSTEIN. See Steatite.

SPECULUM METAL. See Copper, alloys of.

SPELTER.

Is the uſual commercial name for Zinc.

SPERMACETI. *Blanc de Baleine*. Fr. *Wallrath*. Germ.

This peculiar oily ſubſtance is found abundantly in the cranium of the cachalot or ſpermaceti whale (Phyſeter macrocephalus, *Linn.*) and in ſome other ſpecies of the ſame genus: but though contained in the cavities of the ſcull it appears to be entirely different from the proper brain of the animal. When firſt extracted it is mixed with a conſiderable quantity of oil, which is ſeparated by putting the maſs into a woollen bag and preſſing it, by which the greateſt part of the oil runs out, and then waſhing the reſidue with a warm weak alkaline ley, which diſſolves and converts into ſoap the remainder of the oil, leaving behind the ſpermaceti untouched; this latter after being repeatedly waſhed with ſoft water, is melted by a very gentle heat, the impurities partly float on the ſurface, and partly ſink to the bottom, and are thus got rid of; the fluid, in appearance a perfectly pellucid oil, is now allowed to cool, and forms on congealing a maſs of purified ſpermaceti.

The colour of ſpermaceti is a pure brilliant almoſt ſilvery white; it is compoſed of ſemi-tranſparent cryſtalline plates; is ſofter and more brittle than white wax, has very little flavour, and only a ſlight tallowy odour. Its ſuperior tranſparency, high luſtre, and cryſtalline texture, at once diſtinguiſh it from every other ſpecies of concrete oil. Its point of congelation is 112° Fahr. By the aſſiſtance of a wick it burns with a clear white flame, ſuperior to that of tallow, and without any diſagreeable odour, hence its excellence as a material for candles.

Spermaceti by diſtillation at a gentle heat, paſſes over in the ſtate of a fluid oil, which concretes on cooling, a very ſlight carbonaceous reſidue being left in the retort; by repeated diſtillation, however, the ſpermaceti becomes permanently fluid at the common temperature. It requires according to Thouvenel, a much leſs heat for its volatilization than moſt of the other oils do, and therefore is leſs decompoſed by the proceſs; in particular no acid makes its appearance. But according to the experiments of Crell a greater heat is required for its diſtillation than for that of fat, the coagulated oil, thus procured, is partly white and partly browniſh; by repeated diſtillation it affords a yellowiſh acid, becomes more fluid, but ſtill coagulates in the cold. The acid when rectified by diſtillation is entirely colourleſs, and affords the ſame ſalts with earths and alkalies as Crell's ſebacic acid. The oil unites with ammonia into a ſaponaceous emulſion.

Spermaceti is ſoluble in boiling alcohol, though very ſparingly, 150 parts of the menſtruum being required for this purpoſe, and the whole of the ſpermaceti appears to be again precipitated as the ſolution cools.[a] Warm ether diſſolves it very copiouſly, but ſeems to retain none of it when cold. Oil of turpentine has the ſame effect. With cauſtic potaſh it combines into a ſoap, ſoluble in warm water. Fluid ammonia when cold has no action on ſpermaceti, but when warm diſſolves it with great facility, forming an emulſion which is not decompoſed either by ſimple cooling, or by mixture with water; the addition of an acid however inſtantly precipitates the ſpermaceti. With concentrated ſulphuric acid it forms a browniſh ſolution, which when dropped into water gives up its ſpermaceti apparently unaltered. It diſſolves ſulphur as the other fat oils do. By long expoſure to the air it acquires a yellow tinge and becomes rancid.

The great uſe of ſpermaceti is for making candles; it is alſo employed in medicine.

SPINELL, or true Ruby. *Spinell*, Wern. *Spinelle*, Hauy and Broch.

Its colour is red mixed with various tints of blue or yellow; hence it occurs carmine, hyacinth, cochineal, and cherry red, roſe red, and rarely blood red, alſo violet blue, bluiſh green, and orange yellow. It occurs in grains, in ſmall rounded fragments, and cryſtallized.

The primitive form of its cryſtals is the regular octohedron, beſides which it exhibits the following varieties.

1. The cuneiform octohedron.
2. The primitive octohedron with the edges of the common baſe truncated.
3. The ſame with all the edges truncated.
4. The primitive octohedron divided obliquely into two ſegments which are turned on each other $\frac{1}{6}$ of a circle, thus forming a ſolid with alternate ſaliant and re-entering angles.

The cryſtals are ſmall and very ſmall, rarely middle-ſized. The faces of the octohedron are ſmooth, the planes of the truncatures are longitudinally ſtriated. Its luſtre both externally and internally is brightly ſhining, vitreous. Its croſs fracture is conchoidal, its longitudinal fracture is lamellar in three directions. It varies from tranſlucent to tranſparent. Its hardneſs is very conſiderable, though inferior to that of ſapphire. Sp. gr. 3.57—3.64.

It is infuſible before the blowpipe without addition, but it melts with borax and acquires a green colour. When ground to a very fine powder, it is ſoluble by long digeſtion in boiling ſulphuric acid. It was firſt analyſed by Klaproth, and afterwards by Vauquelin, with the following reſults.

Klapr.		Vauq.	
74.5	—	82.47	Alumine
15.5	—	0.	Silex
8.25	—	8.78	Magneſia
1.5	—	0.	Oxyd of iron
0.75	—	0.	Lime
0.	—	6.18	Chromic acid
100.50	—	97.43	

Its geological ſituation is not known; it occurs however imbedded in calcareous ſpar and adularia, accompanied by mica and magnetic pyrites. It is found in Pegu and the iſland of Ceylon.

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[a] Boſtock in Nich. Journ. 8vo. iv. p. 34.

Spinelle ranks among the gems; and is called by different names among the jewellers, according to the tone of its colour. The pure bright red is called *Spinelle*, and is the moſt eſteemed, its value when exceeding 4 carats in weight, being half that of a diamond of equal weight; the orange red variety is called *Vermeille*, or *Rubicelle;* and the roſe red is called *Balais* or *Balaſs* ruby. The oriental ruby is a variety of TELESIA.

SPINTHERE.

The colour of this mineral is greeniſh. It occurs cryſtallized in irregular dodecahedrons, compoſed of a double four-ſided pyramid, obliquely truncated at the apexes. The cryſtals are very ſmall and brightly ſhining; the fracture is lamellar. Its hardneſs is inferior to that of glaſs; it is tranſlucent on the edges.

It melts before the blowpipe without much difficulty. It has not been analyſed.

It was diſcovered by Hauy implanted in calcareous ſpar from Dauphiné.

SPIRITS DISTILLED.

Under the articles *Fermentation*, *Brandy*, and *Alcohol*, we have already given a deſcription of the proceſſes by which ardent ſpirit is made, and of its chemical properties; we ſhall therefore in this place only mention a few circumſtances in the preparation of *corn-ſpirits* and *rum*.

The greater part of the common ſpirituous liquors conſumed in this and other countries of Europe where the vine does not grow, is prepared from fermented corn of one kind or other, mixed occaſionally when it ſuits the purpoſe of the diſtiller with molaſſes, and ſometimes with carrots and other ſub-ſaccharine vegetables. But when there is no ſcarcity of grain, this is by far the greateſt, and often the only ingredient.

The ſpirit thus procured is rectified for ſale by being re-diſtilled with juniper-berries, turpentine, and many other ſubſtances to give it the deſired flavour and appearance.

The grain, if barley is uſed, is generally firſt malted in the uſual manner, and in Scotland is dried with peat, the ſmoke of which gives that peculiar flavour which is found in *whiſky*, the ſpirit diſtilled from it. It is then ground to coarſe powder, maſhed, and the infuſion fermented with yeaſt in large tuns. In this ſtate it is a ſtrong ale, and differs from the malt-liquors uſed for drinking, only in containing no hops nor any other bitter. This fermented liquor is called *waſh*, and is then fit for the firſt diſtillation.

The theory and practice of diſtillation having been deſcribed under the articles *Alcohol* and *Brandy*, we ſhall not here repeat it, except to mention that ſeveral additions are made to the waſh with a view either of increaſing (as is ſuppoſed) the yield of ſpirit, or of correcting and keeping down the eſſential oil derived from the malt which is apt to give it a nauſeous flavour; or of regulating the boiling within the ſtill, and preventing it from boiling over or *running foul;* or of neutralizing the acid generated during the fermentation, which remarkably leſſens the product of ſpirit. For all theſe purpoſes ſoap is accounted the beſt addition, and large quantities of it are employed for this purpoſe in diſtilleries. Others uſe alkalies.

During the diſtillation the firſt ſpirit that comes over (as in the diſtillation of wine) is oily and turbid, and often of a nauſeous flavour, owing to the oil of the malt which accompanies it in all theſe changes. The ſpirit then runs clear and continues ſo to the laſt, but conſtantly decreaſing in ſtrength, becoming more watery, and therefore of leſs ſpecific gravity.

The whole of the ſpirit thus obtained is then again diſtilled or *rectified*, and in this proceſs the middle runnings from the ſtill are received apart from the firſt portion which is too oily and turbid, and from the latter which is too watery to come up to the eſtabliſhed proof. It is in the rectification alſo that the additions which give a peculiar flavour to the ſpirit, (ſuch as juniper berries, &c.) are made.

The general proceſs of the diſtillery is ſimple, and certainly not difficult of management to enſure a certain degree of ſucceſs, ſince it is carried on in the ſmall way by hundreds of ſmall farmers and ignorant perſons in thoſe remote parts of the iſland which offer the greateſt facility of eluding the exciſe duties. But in conducting vaſt and expenſive works a large ſhare of practical ſkill is required, and almoſt every diſtiller profeſſes to have ſome peculiar nicety of practice in the management of the proceſs or the conſtruction of the apparatus.

The form of the ſtill in particular has undergone many ſucceſſive alterations (eſpecially in Scotland, where the mode of levying the duty renders it an object to diſtill as faſt as poſſible) and by gradually widening the bottom and contracting the height of the boiler, diſtillation is now carried on with a rapidity that would almoſt exceed belief were it not perfectly well authenticated.[a] After ſucceſſive improvements and a conſiderably complicated apparatus, a ſtill has been conſtructed which contains only 40 gallons in the body and 3 in the head, in which the time of charging, boiling and running, and letting off the waſte liquor, amounts only to *two minutes and three-quarters* when the charge of waſh is 16 gallons, which is two-fifths of the whole contents. In rectification, which is a ſlower proceſs, the charge is 24 gallons, and the time of diſtilling about ten minutes. This rate of working however is far beyond the ordinary rate.

It is not neceſſary to malt grain in order to make it ferment ſufficiently to yield a good ſpirit, and not only barley but any other grain will anſwer the ſame purpoſe. In this country a mixture of barley and malt is generally preferred; in Holland the very fineſt geneva is made from wheat and malt, but more commonly from malt and rye, which latter yields more ſpirit than wheat. Very ſuperior care and attention ſeems to be beſtowed in conducting the whole proceſs.

The greater number of diſtillers proceed in the following manner.[b] A quantity of rye-flour coarſely ground is mixed with a third or fourth part of malt and put into the fermenting tub with cold water, ſtirring it well with the hands to prevent the meal from clotting. Sufficient water is then added of a blood warmth, after which the ferment is mixed with the whole, which is compoſed of the yeaſt of former operations dried and kept for a certain time. If the weather is favourable and the heat well regulated, the fermentation begins in ſix hours, and terminates on the third day, and the liquor becomes tranſparent and aſſumes a hot pungent taſte. The diſtillation is then proceeded upon immediately, before the liquor turns ſour, which is avoided as much as poſſible. The diſtillation is conducted very ſlowly, that the ſpirit may be as little as poſſible impregnated with the oil of the grain, to which much of the unpleaſant flavour of the ordinary ſpirits is juſtly attributed. The firſt ſpirit is then rectified by a ſecond diſtillation over juniper-berries, or in *double Geneva* by a third proceſs. In ſome of the ordinary ſorts however the juniper-berries are mixed with the fermenting materials, and one diſtillation ſuffices. In the common geneva or gin vulgarly uſed in this country, the fine juniper flavour is coarſely imitated by turpentine.

Rum is prepared by diſtilling a fermented liquor made from melaſſes, and other refuſe ſaccharine matter which is procured during the manufacture of raw ſugar in the Weſt Indies. The common proceſs in Jamaica is the following.[c] The materials for the fermentation are, molaſſes or the treacle which drains from the ſugar, ſcummings of the hot cane juice, or ſometimes raw cane liquor, lees or *dunder* as it is called, and water. The dunder anſwers the purpoſe of yeaſt, and is uſually prepared by a ſeparate fermentation of cane ſweets and water. The materials being mixed in due proportions, (which are about equal parts of ſcummings, dunder, and water) the fermentation begins very ſoon, and in 24 hours the liquor is fit for the firſt charge of melaſſes, which is added in the proportion of 3 gallons for every 100 gallons of the liquor. Another charge is added in a day or two afterwards. The heat in fermentation ſhould not exceed 90° or 94°, ſo that in this climate it is neceſſary to keep the fermenting tubs as cool as poſſible. The fermentation falls in ſix or eight days, and the liquor grows fine and fit for diſtillation. In about two hours after lighting the fire the ſpirit begins to run (in a ſtill of 1200 gallons) and it is collected as long as it remains inflammable.

The firſt ſpirit is called in the country, *low wines*, and it is rectified in a ſmaller ſtill to the Jamaica proof, which is that in which olive oil will ſink. About 220 gallons of proof rum are obtained from 530 gallons of low wines.

SPIRIT OF LIBAVIUS. See Tin.

SPIRIT OF MINDERERUS. See Acetite *of Ammonia*.

SPIRIT OF NITRE. See Nitric Acid.

SPIRIT OF SALT. See Muriatic Acid.

SPIRIT OF SULPHUR, or of VITRIOL. See Sulphuric Acid.

SPIRIT OF TURPENTINE. See Turpentine.

SPIRIT OF WINE. See Alcohol.

SPIRITUS RECTOR. See Aroma.

SPONGE.

This ſubſtance was examined by Mr. Hatchett in his ſeries of valuable experiments on the component parts of animal membrane.[a] When ſponge has been immerſed in dilute nitric acid for a fortnight, the acid becomes pale yellow and is changed to an orange by pure ammonia. The ſponge after this proceſs becomes more or leſs tranſparent, and conſiderably ſoftened, and is then compleatly ſoluble in ammonia into a deep orange-coloured liquor. When digeſted with boiling diſtilled water, ſponge gives out a portion of gelatin, which is precipitated by infuſion of oak-bark. The ſponge by loſing its gelatin, becomes much leſs flexible than before, and is eaſily torn when moiſt, or crumbles between the fingers when dry. When ſponge either in its natural ſtate, or eſpecially when its gelatin has been extracted by long boiling with water, is boiled with cauſtic potaſh, it compleatly diſſolves therein and forms an animal ſoap.

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[a] Report to the Houſe of Commons on the Diſtilleries in Scotland, Dr. Jeffray's Memoir.
[b] Ibid. Mr. Crookeen's Mem.
[c] Edwards's Hiſtory of the Weſt Indies.
[a] Phil. Tranſ. for 1800, p. 352.

Sponge, when heated in a cloſe veſſel, gives out an ammoniacal fetid ſmoke, and is reduced to a black charcoal, which, after incineration, leaves a ſmall quantity of common ſalt and ſome carbonat of lime.

Charred or burnt ſponge is uſed in medicine.

The chief conſtituent parts of ſponge therefore are, animal gelatin, and that condenſed albumen which Mr. Hatchett has found to be the principal part of all ſoft membranous organs, of cartilage, &c. The former is diſſolved, though with ſome difficulty, in boiling water, but does not yield to cold water; the albumen is inſoluble in water at any temperature, but yields to cauſtic alkali.

STAHL's SULPHUREOUS SALT. See Sulphite of *Potaſh*.

STANGENSPATH. See Heavy Spar.

STALACTITE
STALAGMITE See Limestone.

STARCH. Amidon, *Fr.* Starkmehl, *Germ.*

Under the article *Fecula*, the chemical properties of the ſtarch, or fecula of all vegetables, have been deſcribed; we have therefore only in this place to mention ſhortly the mode of manufacturing the common ſtarch which is made, for ſale, almoſt excluſively from wheat. This grain conſiſts of gluten, fecula, a colouring extractive matter, and phoſphat of lime, and it is the object of the ſtarch-maker, to ſeparate the fecula alone from all the other ingredients. This might be done, one would think, ſimply by grinding the wheat into very fine flour, mixing the flour with water into a ſtiff paſte with much beating, and then expoſing this paſte with uninterrupted agitation to a gentle current of pure water, which would run off milky with the ſtarch as long as any of it remained in the paſte, and the gluten alone would be left behind. This milky water would depoſit the ſtarch by remaining at reſt for a time.

A ſimilar method is followed in the ſmall way in making potatoe ſtarch, as mentioned under the article *fecula*, only with leſs labour, as this contains no gluten.

Wheat ſtarch is not made however exactly in this ſimple way, but the grain after being coarſely ground, is ſuffered to ferment or mould with water for many days, by which its texture is entirely broken down, and the ſtarch which is ſcarcely alterable in the proceſs, is probably more effectually ſeparated from all the other ingredients, and obtained finer and whiter. The actual method is (in a few words) the following:[a] The wheat is firſt coarſely bruiſed, and placed in large wooden vats or reſervoirs, water-tight, and intimately mixed with water. Here a fermentation begins after a time, which is a mixture of the vinous and acetous, and is attended with a ſtrong, unpleaſant, ſour, mouldy ſmell. The wheat remains in the vat for about a fortnight, till the fermentation ceaſes, which is known by its ſettling at the bottom of the vat. The contents are then emptied ſucceſſively into a ſmall tub, and mixed with freſh water, till all the pulpy part is thin enough to paſs through a hair ſieve, which ſeparates the bran from it. What has gone through contains the ſtarch ſuſpended in a very ſour water, and conſiderably foul. This is put into tubs or frames, and allowed to remain for two days undiſturbed, during which the impure ſtarch ſettles to the bottom. The water is then drawn off, the frames turned on their ſides, and the dirty diſcoloured part of the ſtarch (which is the laſt that ſubſides and therefore is at the top) is ſcraped off, and the remaining ſtarch is well waſhed and bruſhed, till it is nearly free from this muddy ſediment, which is called *ſlimes*, and is treated ſeparately to obtain its ſtarch. The ſtarch is ſtirred with freſh water, and ſuffered to ſettle, and again cleanſed; till all its impurities are removed, and is then mixed with water enough to make it liquid, and paſſed through a fine lawn ſieve. It is then fit to receive its colour, which conſiſts of ſmalt mixed with water and a ſmall quantity of alum, and is thoroughly incorporated with the ſtarch. After again ſettling, the ſtarch is taken out and put into oblong boxes, about ſix feet long and one broad, with holes at the bottom, and lined with linen cloth, where the moiſture of the ſtarch drains off till it becomes ſolid enough to be cut into ſquare lumps. Theſe are laid on new bricks which abſorb much of their moiſture, and make them hard enough to be ſtoved. Here the ſtarch remains in a moderate heat, till a ſlimy cruſt riſes to the ſurface, which is carefully ſcraped off, and the reſt, which is now perfectly pure ſtarch, is papered and placed again in the ſtove with a good hot fire, till quite dry. This laſt ſtoving cauſes the lumps to crack pretty uniformly into the ſmall pieces in which they appear when ſold. The *ſlimes* are all treated in the ſame way till all the ſtarch is got from them. All the refuſe matter from ſtarch making makes very valuable food for fattening hogs. The whole time of making ſtarch, from the firſt ſteeping of the wheat to the laſt ſtoving, is about ſix weeks; and 551 Wincheſter buſhels of wheat will make about ſix ton of ſtarch. This will be about $\frac{7}{17}$ of the entire weight of the wheat.

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[a] Original Communication.

In the proceſs of ſtarch-making a great quantity of a ſour nauſeous milky water is obtained, from which the ſtarch ſubſides after it is firſt removed from the fermenting vat. This has been analyzed with great care by Vauquelin, with the following reſults.

This liquor has an acid, and at the ſame time a ſpirituous flavour, it ſtrongly reddens litmus, gives a precipitate with lime-water, which an exceſs of the liquor re-diſſolves. Alcohol added to it gives a white, light, ſoft precipitate. Oxalic acid alſo gives a precipitate, which ſhews that the acid contained in the liquor is not the oxalic.

A quantity of this liquor was diſtilled. The firſt product was ſenſibly ſpirituous, and yielded on rectification a notable quantity of pretty pure alcohol. After this, an acid liquor came over, which gave a ſalt reſembling exactly acetite of lead when ſaturated with litharge, acetite of lime, with lime, and therefore was acetous acid. The reſidue in the retort, after moſt of the liquor had diſtilled off, was reddiſh-brown, had a very ſour taſte mixed with that of burnt bread, and a ſyrupy conſiſtence. It was filtered, and the clear liquor gave with lime-water an abundant precipitate, which an exceſs of the liquor rediſſolved; with cauſtic alkalies a ſimilar precipitate was alſo formed, along with an obvious production of ammonia; and with oxalic acid, oxalat of lime was produced. With the ſolutions of lead a white precipitate fell down, and this latter decompoſed by ſulphuric acid, gave another acid which in every reſpect agreed with the phoſphoric.

The ſtarch-ſours therefore contain, beſides a viſible white matter ſeparable by filtering, a quantity of phoſphat of lime and ammonia, both held in ſolution by the acetous acid which is generated ſo abundantly by the fermentation. A peculiar animal matter is alſo found in this acid liquor, which ſeems to reſemble *gluten*, and therefore which only belongs to that ſtarch which is made from wheat flour.

This liquor therefore contains the five following ſubſtances, viz. acetous acid, ammonia, alcohol, gluten, and phoſphat of lime, but of theſe only the two laſt are natural to the wheat; the others are the products of the fermentation, the ammonia being generated by the decompoſition of part of the gluten, the alcohol by the ſaccharine mucilage which all grain contains, and the acetous acid perhaps from all the other principles. The peculiar office which this acid performs in ſtarch-making is to diſſolve the gluten and phoſphat of lime, and thus to ſeparate them from the pure ſtarch. Hence when wheat is the grain employed, ariſes the neceſſity of continuing the fermentation long enough to generate a ſufficient quantity of acetous acid; for the other grains and roots which yield ſtarch contain little or no gluten. A conſiderable quantity however of the ſtarch muſt be deſtroyed in the proceſs, for wheat contains much more of it than is obtained in manufacture, as may be found by waſhing flour paſte with water in the way mentioned in the beginning of this article.

STAUROLITE. Granatite, *Sauſſure* and *Wern.* Staurotide, *Hauy.*

Its colour is reddiſh or blackiſh-brown. It occurs always cryſtallized. The form of its cryſtals is a hexahedral priſm, of which four faces are by much the largeſt and meet in pairs, forming two obtuſe oppoſite angles, meaſuring 129°. This priſm is either entire or truncated on the obtuſe angles. It is not uncommon to find two cryſtals penetrating each other obliquely or at right angles, ſo as to form a croſs; ſometimes even three priſms are thus arranged, forming a triple croſs. Its ſurface is ſmooth or uneven, and its luſtre varies accordingly. Internally it is more or leſs ſhining, with a luſtre between vitreous and reſinous. Its fracture parellel to the axis is imperfectly lamellar: in the oppoſite direction it is ſmall-grained uneven, paſſing to conchoidal. It is brittle, and ſomewhat harder than quartz. Sp. gr. 3.28.

When expoſed to the blowpipe it undergoes no other change than that of fritting a little on its ſurface. Its component parts according to an analyſis by Vauquelin, are

	33.	Silex
	44.	Alumine
	3.84	Lime
	13.	Oxyd of iron
	1.	Oxyd of manganeſe
	94.84	
Loſs	5.16	
	100	

It is found in St. Gothard in Switzerland, in ſmall cryſtals imbedded in micaceous ſchiſtus, and accompanied with cyanite; in Brittany near Quimper, in middling ſized cryſtals, imbedded in a micaceous clay, apparently produced by the decompoſition of ſome primitive rock: alſo at Sant Jago of Compoſtella, in a primitive rock.

STAUROTIDE. See the preceding article.

STEATITE. Speckſtein, *Wern.* Soapſtone, Spaniſh Chalk, Craie de Briançon.

Its colour is greyiſh, greeniſh, yellowiſh, or reddiſh-white, alſo fleſh-red, mountain-green, and olive-green: the whitiſh varieties generally contain black dendritical figures and ſpots. It occurs in maſs, diſſeminated, inveſting and cryſtallized. The forms of its cryſtals are a ſix-ſided priſm, terminated by ſix-ſided pyramids; alſo a rectangular and rhomboidal four-ſided priſm; alſo a double ſix-ſided pyramid. It is probable however that ſeveral if not all of theſe are pſeudomorphous. The cryſtals are ſmall and middleſized, generally imbedded in the maſſive kind, and are very rare. Internally it is dull, or at moſt faintly glimmering. Its fracture is coarſe ſplintery, rarely earthy, and ſometimes intermediate between coarſe fibrous and foliated. It is tranſlucent on the edges, rarely tranſlucent. It is ſoft and very ſoft, gives a ſhining ſtreak, may be cut with a knife, is not very frangible, is very unctuous to the touch like ſoap. Sp. gr. 2.64. Before the blowpipe it becomes hard and generally loſes its colour, but is not fuſible without addition.

The ſteatite of Bareuth, according to the analyſes of Klaproth and Wiegleb, conſiſts of the following ingredients.

Klap.		Weigl.	
59.5	—	58.33	Silex
30.5	—	39.16	Magneſia
2.5	—	2.5	Oxyd of iron
5.5	—	0.	Water
98.0		99.89	

The ſteatite of Cornwall, according to Klaproth, conſiſts of

48	Silex
20.5	Magneſia
14.	Alumine
1.	Oxyd of iron
15.5	Water
99.0	

It occurs in beds and veins in ſerpentine, alſo in nodules in various other rocks, particularly thoſe of the Floetz-trap formation. It is found in Cornwall at the Lizard Cape, imbedded in ſerpentine, alſo at Portſoy, in Scotland, in ſerpentine, and in the Iſle of Skye in wakke. It abounds in the principality of Bareuth, in Saxony, Bohemia, Norway, Sweden, and France.

The white varieties and thoſe that become ſo by calcination, are employed in the manufacture of the fineſt porcelain. Other varieties are ſaid to be uſed for fulling.

STEEL. See IRON.

STEEL ORE.

A common name for ſpathoſe iron ore: ſee IRON, p. 516.

STILL. An article of chemical apparatus. See the Appendix.

STINKSTEIN. See SWINSTONE.

STILBITE. See ZEOLITE.

STRAHLSTEIN. *Actynolite*, Kirw. *Actinote*, Hauy. *Rayonnante*, Broch.

Of this mineral there are the three following ſubſpecies.

1. *Subſp.* Common Strahlſtein.

Its colour is olive or leek green, mountain green, blackiſh green, reddiſh, yellowiſh, or greeniſh white, liver brown, and reddiſh brown. It occurs in maſs, diſſeminated or cryſtallized. The primitive form of its cryſtals is a very oblique rhomboidal priſm, the alternate angles of which are 124° and 56°. Sometimes the priſm is truncated on its acute lateral edges as well as on its terminal angles and edges. It alſo occurs in ſlender needle-ſhaped cryſtals. The cryſtals are ſtriated longitudinally, and are very brilliant externally. Internally this mineral is more or leſs ſhining, with a vitreous luſtre. Its fracture is broad radiated, either parallel, diverging, bundled, or in ſtars, very rarely lamellar. Its fragments are ſometimes wedge ſhaped, but more commonly indeterminate, blunt edged. It occurs in wedge ſhaped priſmatic, and in granular diſtinct concretions. The cryſtals are tranſlucent, and even ſemi-tranſparent: the other varieties are only translucent on the edges. It is conſiderably hard and brittle. Sp. gr. 3.—3.3.

It is fuſible before the blowpipe into a vitreous ſcoria of a black or grey colour.

Its component parts according to Bergman are

64.	Silex
20.	Magneſia
2.7	Alumine
9.3	Lime
4.	Oxyd of Iron
100.0	

The maſſive varieties occur in beds in primitive mountains, accompanied by galena, pyrites, and magnetic iron ore: the cryſtallized varieties occur in dolomite, foliated talc, and in veins of the oldeſt formation, accompanied by mica, titanium, &c. It abounds in the Tyroleſe Alps, particularly in the Zillerthal, alſo in the Italian Alps, in Saxony, in Norway, and in ſome parts of the north of Scotland.

2. *Subſp.* Aſbeſtiform Strahlſtein.

Its colours are greyiſh or greeniſh white, reddiſh or yellowiſh white, olive green, mountain green, ſmalt blue, and liver brown. It occurs in maſs, diſſeminated, and ſometimes in brilliant, flexible, elaſtic, capillary cryſtals. Internally it is gliſtening, with a pearly luſtre. Its fracture is divergingly radiated, or ſlender fibrous. It occurs in coarſe and wedge ſhaped priſmatic diſtinct concretions. It is ſometimes tranſlucent at the edges, but more commonly opake. It gives a greeniſh white ſtreak; is moderately hard, approaching to ſoft; is brittle but not very frangible. Sp. gr. 2.5 to 2.9.

It is fuſible before the blowpipe without addition into a black or grey ſcoria.

It occurs at Raſchau in Saxony mixed with green copper ore and pyrites; in Bareuth, mixed with ſerpentine and ſteatite: it alſo occurs in the Bannat.

3. *Subſp.* Glaſſy Strahlſtein. *Epidot*, Hauy. *Acanticonite*,—*Arendalite* of ſome authors.

Its colour is olive green, paſſing into graſs green, mountain green, and browniſh green. It occurs in maſs, or cryſtallized in hexahedral priſms, often laterally aggregated. The ſurface of the cryſtals is ſmooth and brightly ſhining. Internally it is more or leſs ſhining with a vitreous luſtre. Its fracture is between radiated and fibrous. It occurs in ſlender priſmatic, or granular diſtinct concretions. Its fragments are ſplintery and wedge ſhaped. It is tranſlucent paſſing to ſemitranſparent; is moderately hard, very brittle, and eaſily frangible. Sp. gr. 2.9—3.49.

The Arendalite has been analyzed by Vauquelin, and the epidot of the Alps by Collet des Cotils with the following reſults.

Vauq.		Coll.	
37	—	37	Silex
21	—	27	Alumine
15	—	14	Lime
24	—	17	Oxyd of Iron
1.5	—	1.5	Oxyd of Manganeſe
98.5	—	96.5	

It occurs in the ſame ſituations as the common ſtrahlſtein; and alſo at Arendahl in Norway in veins mixed with quartz, garnets, and magnetic iron ore.

There is a great analogy between the ſeveral ſubſpecies of ſtrahlſtein, and hornblende, tremolite and aſbeſtus.

STRONTIAN.

This alkaline earth was firſt procured from its native carbonat found at ſtrontian in Argyleſhire, whence its name. It has ſince been found near Briſtol and in various other places, combined with ſulphuric acid. The pure earth may be obtained either from the carbonat or the ſulphat by the ſame proceſſes as thoſe employed in procuring pure Barytes: as the native carbonat of ſtrontian is however conſiderably rarer than the carbonat of barytes, the moſt economical method upon the whole of preparing pure ſtrontian is to mix the native ſulphat of this earth (being previouſly well levigated) with twice its weight of cryſtallized carbonat of potaſh, and expoſe the maſs to a moderate red heat for half an hour in a ſilver crucible, or boil it for an hour with diſtilled water. By this proceſs a double decompoſition takes place, the ſulphuric acid quitting the ſtrontian to unite with the potaſh, while the carbonic acid of this latter combines with the ſtrontian: the maſs is now to be waſhed with hot water till the ſulphat of potaſh is diſſolved out, and nothing remains but carbonat, and probably a little undecompoſed ſulphat of ſtrontian: diluted nitric acid being now added, nitrat of ſtrontian will be contained in ſolution: the clear filtered liquor by evaporation and cooling will depoſit the ſalt which it contains in cryſtals, and theſe being ignited in a platina crucible till the acid is entirely decompoſed and driven off, there will remain behind a ſomewhat indurated maſs of a grey colour, which is pure ſtrontian.

Strontian has a hot pungent acrid taſte greatly reſembling that of quicklime; when expoſed to the air it ſoon abſorbs moiſture and falls to pieces, and in a few days after becomes ſaturated with carbonic acid. If water is poured upon it when recently calcined, the fluid is eagerly abſorbed, a copious extrication of heat takes place, and the maſs falls into a bulky powder. Strontian is not very ſoluble in cold water, an ounce of this fluid at 60° taking up no more than 2.7 grs.[a] This ſolution is perfectly clear and limpid; it taſtes like limewater and changes vegetable blues green like the other alkaline ſubſtances. On expoſure to the air it becomes covered with a pellicle of regenerated carbonat of ſtrontian, which being removed or falling to the bottom, another ſucceeds, and ſo on till the whole of the earth is precipitated in the ſtate of carbonat. Boiling water however takes up a much larger proportion of ſtrontian than cold does, in conſequence of which as the ſolution cools it depoſits the exceſs of this earth in a cryſtalline ſtate. The forms of theſe cryſtals are quadrangular plates either plane or bevilled at the edges, or cubes or parallelopipeds.

Theſe cryſtals by expoſure to the air become of an opake white colour, and ſoon fall to powder: by this change they loſe about 10 per cent. notwithſtanding the large quantity of carbonic acid that they imbibe: this loſs is entirely water, the recent cryſtals containing full 68 per cent. of this ingredient. Of theſe cryſtals one ounce of water at 60° will diſſolve 8.5 grs. and the ſame quantity when boiling will take up no leſs than 218 grs.

Strontian combines with all the acids, forming with them neutral ſalts, which though they bear a general reſemblance to thoſe of barytes, yet differ from them in various particulars, for an account of which we refer to the ſalts themſelves.

Silex and alumine are rendered ſoluble in water by means of ſtrontian in the ſame manner as by the fixed alkalies and barytes, only a larger proportion is required of ſtrontian than of the reſt. Sulphur combines with ſtrontian by fuſion, into a ſulphuret, or by boiling with a ſolution of this earth, into a hydroſulphuret. The ſulphuretted hydrogen that is diſengaged from either the one or the other on the addition of muriatic acid, carries off with it a little ſtrontian, and in conſequence burns with a red purple flame inſtead of the blue flame of pure ſulphuretted hydrogen.

Alcohol takes up a ſmall proportion of ſtrontian, and in conſequence burns with a purple flame: this character in particular diſtinguiſhes it compleatly from barytes which communicates a pale yellow colour to the flame of alcohol.

Strontian when expoſed to the blowpipe is not fuſible as barytes is, but it emits during the action of the flame an intenſely dazzling white light. For further particulars of reſemblance and difference between theſe two earths, ſee BARYTES.

The order of affinity between ſtrontian and the ſeveral acids is thus ſtated by Dr. Hope: ſulphuric, oxalic, tartaric, fluoric, nitric, muriatic, ſuccinic, phoſphoric, acetic, arſenic, boracic, carbonic.

The affinity of barytes for the acids appears to be in all caſes greater than that of ſtrontian for the ſame: but this latter on the other hand generally takes the precedence of the fixed alkalies, eſpecially where the reſulting ſtrontian ſalt is much leſs ſoluble than the correſponding one of potaſh or ſoda. But in the attraction for nitric, muriatic, acetic, and ſuccinic acids, the fixed alkalies are conſidered as ſuperior to ſtrontian. The decompoſition however which they are able to effect of theſe ſtrontitic ſalts is very imperfect, as was firſt ſhown in the caſe of muriatic acid by Dr. Hope. This able chemiſt diſſolved 200 grs. of native carbonat of ſtrontian in muriatic acid diluted with an equal bulk of water, and when the ſolution was compleat, he added an exceſs of liquid potaſh, but no more than 24 grs. of ſtrontian were precipitated; he then poured in carbonated potaſh, and 170 grs. of carbonated ſtrontian were obtained. The ſame experiment was repeated, except that the cauſtic potaſh was dropped in very ſlowly, by which proceſs 74 grs. of ſtrontian were depoſited, and the ſubſequent addition of carbonated alkali threw down 132 grs. more of carbonated ſtrontian.

STRONTIANITE. *Strontianit*, Wern.

Its colour is clear aſparagus green, paſſing to greeniſh or yellowiſh white, or apple green. It occurs in maſs, the rifts or cavities of which are often lined with bundles of acicular cryſtals the form of which approaches to the four or ſix-ſided priſm. Its longitudinal fracture is narrow, ſtrait, and divergingly radiated, with a ſhining pearly luſtre: the croſs fracture is fine-grained uneven, paſſing to ſplintery, and its luſtre is only glimmering. Its fragments are wedge-ſhaped or indeterminate. It occurs in thin ſcapiform, and wedge-ſhaped diſtinct concretions. It is more or leſs tranſlucent, ſometimes, in thin pieces, ſemi-tranſparent: it is moderately hard, brittle, and eaſily frangible. Sp. gr. 3.67 *Klapr.* 3.4—3.64 *Kirw.*

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[a] Hope, in Edin. Phil. Tranſ. for 1798, p. 3.

Before the blowpipe it becomes white, and calcines, but does not melt. When ſtrongly heated in a clay crucible it runs into a denſe, hard, clear, yellowiſh green glaſs, with a loſs of 30 per cent. When intenſely heated in a charcoal crucible, it becomes of a grey colour, and loſes 31 per cent. of its original weight, but does not melt. In diluted nitric or muriatic acids it diſſolves readily with a copious efferveſcence.

It has been analyſed by Hope, Klaproth, and Pelletier, with the following reſults:

Hope.		Klapr.		Pellet.
61.21	—	69.5	—	62 Strontian
30.2	—	30.	—	30 Carbonic acid
8.59	—	0.5	—	8 Water
100		100		100

It has hitherto been found only at Strontian in Argyleſhire, in a vein paſſing through gneiſs, and accompanied by galena, heavy ſpar, calcareous ſpar, and iron pyrites.

STYRAX. See the articles Resin and Benzoic Acid.

SUBERIC ACID. See Cork.

SUBLIMATE CORROSIVE. See Mercury, *Muriat of.*

SUBLIMATION. *Sublimiren*, Germ.

Sublimation is in the dry way what diſtillation is in the moiſt. Thus if a ſmall quantity of ſal ammoniac is put into a flaſk, and heat is applied at the bottom, the entire ſalt riſes in the form of white ſmoke, and condenſes in the upper part of the flask in the form of minute cryſtalline particles, which is a *ſublimate.*

Sublimation is conveniently performed in the ſmall way in common flasks, eſpecially the Florence oil flasks, which being of green glaſs, bear a low red heat very well.

In the large way, as in the making of camphor or ſal ammoniac, it is alſo performed in very large glaſs globes or earthen cucurbits, or ſometimes, though rarely, in a ſeries of earthen veſſels called *Aludels*, for which ſee the Appendix.

SUCCINIC ACID. See Amber.

SUGAR. *Sucre*, Fr. *Zucker*, Germ.

Sugar if pure is a ſubſtance perfectly tranſparent and colourleſs when cryſtallized, but when granular, of a pure gloſſy white, ſoluble in water and alcohol, without ſmell, and with the taſte of ſimple ſweetneſs without any other flavour whatever. It melts by heat into a clear yellowiſh tenacious liquid, and when kindled burns with a ſtrong flame, and a very pungent acid vapour. With the nitric acid it is convertible chiefly into the oxalic acid. It is a moſt powerful antiſeptic, and is one of the moſt grateful, and (when in mixture) one of the moſt nutritive of all the alimentary ſubſtances derived from the vegetable kingdom.

Sugar is never found pure and very rarely in a ſtate approaching to purity, for it is always intimately combined with mucilage and other vegetable principles, to which it largely imparts its peculiar taſte.

Sugar is very extenſively diffuſed over the vegetable kingdom: in general it is elaborated by the growth of the plants that yield it, being chiefly found when the vegetable has arrived at the ſtate of maturity.

The great ſources of ſugar are, the common juice or ſap of plants, as in the ſugar-cane, and maple ſap,—the ripe fruit, as in the grape, date, fig, in all of which it exſudes and effloreſces on the ſurface when kept dry—and the root (though in much ſmaller quantity) as in the beet and parſnip. It is alſo elaborated during the firſt germination of moſt grains, particularly barley, as is ſeen in the proceſs of malting.

Sugar is ſcarcely if at all contained in any part of the animal kingdom (honey belonging certainly to the vegetable) except in milk, and in the urine during that ſingular diſeaſe, the diabetes mellitus.

As almoſt all the ſugar uſed by man is obtained from the ſugar-cane, we ſhall firſt deſcribe the whole proceſs of obtaining it from this moſt excellent vegetable, and alſo from a few other ſources though of trifling importance compared with the firſt.

The ſugar cane[a] (*Saccharum Arundinaceum*) is a jointed reed terminating in ſharply ſerrated leaves. The body of the cane is ſtrong, brittle, and when ripe of a fine ſtraw-colour, and it contains a ſoft pithy ſubſtance which affords a large quantity of that ſweet luſcious agreeable juice from which the ſugar is manufactured. The average height of the mature cane varies from $3\frac{1}{2}$ to 7 feet, or ſometimes much higher, and in rich lands it puts forth a profuſion of ſuckers from which the plant is propagated.

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[a] Edwards's Hiſtory of the Weſt Indies

The entire cultivation of the ſugar-cane is laborious and expenſive, but does not belong to the preſent ſubject. The canes when ripe are cut cloſe to the root and are paſſed between iron cylinders in a very powerful mill, by which all the juice is preſſed out, and the cane itſelf is ſo broken down and compreſſed as to be quite dry and powdery. It is then called *cane traſh*, and is uſed as fuel in the ſubſequent operations.

The cane juice conſiſts of water, holding diſſolved a quantity of pure ſugar, of tenacious mucilage, and of eſſential oil, but no very exact chemical analyſis has been made of it. The proportion of ſugar in good cane juice may be reckoned about one-eighth in weight, for (in Jamaica at leaſt) a pound of ſugar from a gallon of juice is reckoned a good yield. The juice beſides has many impurities ſuſpended in it, ſuch as pieces of the cane leaf and ſtalk, a black, hard, probably ſiliceous cruſt, which ſurrounds the joints of the cane, and common dirt of the ſoil. It is the object of all the ſubſequent proceſs to ſeparate the pure ſaccharine part from the other ingredients.

As cane juice is extremely liable to fermentation, it could not remain at reſt in any quantity for twenty minutes without fermenting, therefore the canes are both preſſed as ſoon as cut, and the juice paſſes to the boiler immediately after it is delivered from the mill. The boilers are large copper pans called *clarifiers*, with a fire beneath, the fuel of which is the cane traſh. When the clarifier is filled and the fire lighted, the *temper*, which is Briſtol lime ſlacked till it falls to powder, is added, with the intention of neutralizing the ſuperabundant acid ſuppoſed to exiſt in the juice. From half a pint to a pint of lime is allowed for every 100 gallons of liquor. As the liquor grows hot a thick ſcum riſes to the ſurface, and the heat is raiſed nearly to boiling, but not entirely, that the agitation of boiling may not break the ſcum and again mix it with the liquor. After about forty minutes from filling the copper the fire is damped, and when the liquor has remained at reſt for an hour, the clear part is drawn off with a ſyphon, the ſcum falling down unbroken to the bottom. The liquor (if the canes were good) is now clear and nearly tranſparent, and paſſes immediately to the *grand* or *evaporating* copper. Here the juice is brought to boil as ſoon as poſſible, and as the ſcum riſes it is continually taken off, till the liquor is ſufficiently reduced by evaporation to be contained in a ſecond and ſmaller copper into which it paſſes, and where it is further reduced by boiling, with occaſional addition of lime-water if it continues foul, till the quantity is no greater than will fill the laſt and ſmalleſt copper called the *teache* where the laſt evaporation is conducted. The colour of the juice progreſſively deepens as it becomes more concentrated. In the *teache* the juice is evaporated till it becomes extremely thick and tenacious, and is now ſo ſaturated with ſugar that the latter will ſeparate in diſtinct grains on cooling. The way of judging when the thickening of the hot liquor has arrived at this point is, to take up a little of it with a ladle, and as it cools to moiſten the finger and thumb with it, and draw it out in a thread till it breaks, the length of which depends on the thickneſs of the liquor.

The whole of the contents of the teache are then emptied into ſhallow wooden coolers, where the ſugar *grains* or runs into a coarſe irregular maſs of imperfect cryſtals involved in a dark treacly fluid.

The ſugary maſs is then paſſed to the curing houſe, which is a large airy building, provided with a capacious ciſtern, the ſides of which are ſloped and lined with tarraſs. Over this ciſtern is a frame of maſſy joiſt-work, on which are arranged a number of empty hogſheads without headings, in the bottoms of which holes are bored, through each of which the ſtalk of a long plantain leaf is thruſt, that ſerves as a ſtrainer. The granular maſs of ſugary extract is then laded out of the coolers into theſe hogſheads, where the melaſſes or treacley part gradually oozes through the ſpongy ſtalk of the plantain, and drops into the ciſtern below, and the granulated ſugar remains. In about three weeks the ſugar is tolerably dry and fair, and is then fit for exportation as *Raw* or *Muſcovado Sugar*.

Raw ſugar is a yellow granular maſs, more or leſs brown according to its purity, clammy to the touch, reſembling coarſe ſand in appearance, and evidently compoſed of roundiſh grains of ſugar of different ſizes and hardneſs.

All the ſubſequent refining of raw ſugar to bring it to the ſtate fit for conſumption is performed in this country, but in the French Weſt India Iſlands, much of the raw ſugar undergoes the further operation of *claying*, by which it is purified to a great degree, and becomes whiter and cleaner by the ſeparation of a large portion of the melaſſes, and is univerſally uſed in that ſtate to ſweeten coffee and for moſt domeſtic purpoſes. This proceſs produces the moiſt granular ſugar, ſimilar to that called in this country *Liſbon ſugar*, which is highly agreeable and uſeful, though it is far ſhort of the purity of the loaf ſugar. The clayed or Liſbon ſugar is made in the following way: A quantity of ſugar from the cooler, inſtead of going to the common curing houſe, is put into conical earthen pots with the points (perforated with a ſmall hole) ſet downwards and immerſed a little way in other earthen jars to receive the drippings. This hole is at firſt cloſed with a plug, till the warm thick ſugar liquor has become ſolid by cooling, which is known by the cruſt at top falling in. The plug is then drawn, and the ſyrup allowed to drain into the pots below for ten or twelve hours. After this, ſome clay mixed with water to the thickneſs of cream is poured on the top of the congealed ſugar, and the water from the clay oozing down through the ſugar, carries out with it at the plug hole, moſt of the melaſſes that the mere draining would not ſeparate. The claying is repeated a ſecond or third time, by which the ſugar remaining beneath it is made very white and pure. The pots remain for twenty days in this ſituation, after which the ſugar is taken out, dried in the ſun for ſome hours, and then taken to a large ſtove-room, where it is kept in a pretty ſtrong heat for three weeks.[b]

The Cochin Chineſe prepare a very excellent moiſt ſugar remarkably cheap, by a very ſimple proceſs which acts ſimilar to the claying.[c] The grained ſugar after the groſs ſyrup has drained off from it, and it has become conſiderably ſolid, is placed in layers of about an inch thick, under layers of equal dimenſions of the herbaceous trunk of the plantain tree, the watery juices exſuding from which, act like claying, and leave the ſugar very white, and porous like a honeycomb. It is ſufficiently pure to diſſolve in water without leaving any ſediment.

All theſe methods however will not produce a hard white-grained full-bodied ſugar comparable to the fineſt loaf-ſugar as is made in this country, for the moiſt ſugars are ſtill conſiderably loaded with melaſſes, and are particularly inferior to the loaf in preſerving all kinds of fruits and vegetables.

The following is the general method of making loaf-ſugar in England, which is on the whole extremely ſimple in theory, though a good deal of ſkill is required in the management.

The raw ſugar is firſt coarſely ground, and about three hogſheads of it are put into a copper pan and diſſolved in lime-water. Some coagulable ſubſtance is then uſed to clarify it. The whites of eggs are on the whole the beſt for this purpoſe, and large quantities of ſea-birds' eggs uſed to be imported into London for the purpoſe, but being expenſive, bullocks' blood is now almoſt univerſally ſubſtituted to eggs which is mixed thoroughly with the diſſolved ſugar. It is then brought nearly to boiling, during which the blood coagulates and carries up with it, in the form of a tough ſcum, moſt of the impurities of the ſugar. This ſcum is ſeparated by ſtraining the whole through a blanket, and the clear liquid is now fit to be boiled down. This evaporation is performed in the copper pans at a boiling heat, a neceſſary inconvenience of which, however, is that the heat required gives a dark colour to the maſs, which muſt conſiderably lengthen the future operations. The ſugar-boiler judges by the appearance and thread of the ſyrup when it is boiled enough, at which time it is very thick and rich, and its boiling temperature is about 232°. It is then let off into a large cooler, and when it is judged to be ſufficiently cooled, it is ſtirred for a conſiderable time with wooden paddles fixed to long poles till the ſugar begins to granulate, and the whole mixture to become thick and opake. This occurs when the temperature has fallen to about 190°, and it is then fit to be poured into the moulds. Theſe are large conical earthen pots with a hole through the cloſed or ſmaller end, and of different ſizes; thoſe intended for the fine-loaf ſugar holding about 10 or 12 lbs. of ſyrup, and about twice as much for the inferior lump ſugar. Each of theſe has its earthen jar beneath, into which it deſcends low enough to be firmly ſupported, and which is intended to receive the drainings of the ſyrup or treacle. The moulds with theſe pots are ranged in cloſe rows in all the ſtories of the building above the ground floor (where the pans and furnaces are fixed) and the whole houſe is heated by iron flues, to keep up a pretty warm temperature during the whole time that the ſugar is preparing.

The ſyrup, thickened by ſtirring, and cooled down to about 190°, is then poured into the moulds, the bottom hole being firſt plugged up, and in about four hours the contents have hardened into a ſolid maſs of ſugar, except a portion of uncongealable ſyrup which remains at the bottom. The plug is then withdrawn, and the ſugar in the mould is allowed to drain for about 36 hours undiſturbed. The *green ſyrup* as it is called, or that which falls during all this time, is carefully collected and kept apart from the coarſer ſyrups. It is browniſh, but free from any burnt taſte, and is ſtill very rich in ſaccharine matter. It is uſually mixed in certain proportions with the raw ſugar in the next boiling, ſo that in fact the contents of every boiling conſiſt of raw ſugar and the ſyrups of previous operations in regular ſucceſſion.

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[b] Dict. d'Hiſt. Nat. Article CANNE.

[c] Macartney's Embaſſy to China.

The ſugar from which the green ſyrup has ſubſided is now of a better colour, and much purer than the raw ſugar, but it is brought to its higheſt degree of purity by claying.

A mixture of pipe-clay and water is then poured on the ſurface of the mould and allowed to remain for four or five days, during which the clay dries, ſhrinks, and at laſt readily comes off in a ſolid cake. In general two more clays are added ſucceſſively at the ſame interval. If the loaf is examined in different periods of the claying, the upper, or broader end, will be found hard and white, and the brown treacly ſyrup which it is the object of claying to get rid of, will be ſeen gradually ſettling towards the point of the loaf, and at laſt will be totally expelled and fall into the pot below. A fine loaf therefore is not conſidered as perfectly clayed till the lower part fully equals the upper in whiteneſs. There is alſo conſiderable difference in the colour and fineneſs of the ſyrup during the ſucceſſive clayings, that of the firſt clay being in this caſe the coarſeſt; and the others much purer, for the two laſt clays are only employed in cleaning the very point of the loaf, ſo that the ſyrup from theſe muſt contain a good deal of pure ſugar which the moiſture from the clay has diſſolved before it reaches the ſyrup. When the claying is compleated the moulds are left undiſturbed for a day or two, after which the loaves of ſugar are turned out, and are then ſolid, white, and pure. To dry them compleatly they are put for three or four days in a ſmall chamber heated by a ſtove ſo ſtrongly that a perſon unuſed to it could hardly remain in for half a minute, and here the ſugar is rendered much more hard, white, and beautiful. It is then taken out, and is fit for ſale.

All the ſyrups and runnings from the moulds are more or leſs rich in ſugar, and are all treated in a ſimilar manner with the raw ſugar, to make loaves or lumps of inferior quality, and the ſyrups from theſe again are worked as before for a ſtill coarſer kind. The moſt ordinary loaves are called *baſtards* and are made entirely from the green or firſt ſyrups of the coarſer loaves, without any admixture of raw ſugar. The baſtard loaves require more heat than the finer ſorts, the treacly part being much more viſcid, and they remain longer on the moulds before claying. They are alſo only ſlightly clayed, for the runnings from theſe form *common treacle*, the price of which is ſo much inferior to any ſolid ſugar, however brown, that it is an object to the manufacturer to leave as much treacle as poſſible in the coarſer loaves, conſiſtently with giving them a ſaleable colour and grain. Hence the texture of theſe loaves is much ſofter and more open, and the grain looſe. The lower part of the baſtard loaves, which is much more diſcoloured than the upper, even after claying, is cut off, and when ground it forms the moſt ordinary kind of moiſt ſugar, and the upper part of the ſame loaves forms the common moiſt ſugar. But the fineſt white moiſt ſugar is clayed muſcovado, prepared in the French manner in the Weſt Indies, as already mentioned.

Sugar Candy.

Sugar candy is ſugar brought to a regular form by ſlow cryſtallization. The management of it differs conſiderably from that of loaf ſugar. To prepare it the ſyrup is clarified as uſual, and boiled down to a certain point, but not ſo much as for making loaf ſugar. It is then poured into large oblong moulds or boxes, into which a light frame is previouſly fixed, holding ſtretched from one end to the other a number of cords of packthread. The mould filled with ſyrup, is then put into the drying ſtove, and ſuffered to remain undiſturbed for a conſiderable time, during which the ſugar gradually depoſits in cryſtals around the threads. The mould is then removed, and the frame is lifted out, with every thread thickly and very beautifully encruſted with the candy, and is afterwards drained to free it from the adhering ſyrup. Sugar candy differs from common ſugar in being much harder and tranſparent. The brown ſort cryſtallizes full as regularly as the white, but becomes clammy and deliqueſcent in a damp air, whereas the white candy remains always dry. On account of its ſuperior hardneſs it is leſs eaſily ſoluble than the loaf ſugar, and appears to have much leſs taſte, but it has full as ſtrong a body of ſugar, and would be excellently calculated for preſerving all vegetable food, if the price was lower. The ſole difference between the white candy and the fineſt loaf appears to be in the form, which in the candy is the natural ſaline form of ſugar, but in the loaf is granular, owing to the agitation given to it for this expreſs purpoſe whilſt cooling. The commoneſt form of the regular cryſtals of ſugar candy is an oblique four-ſided priſm, terminated by dihedral ſummits.

A valuable ſugar is extracted in many of the States of North America, from the juice or ſap of the ſugar-maple.[d] The tree is tapped with an augre, which is introduced about two inches, and a projecting ſpout is made below it, under which troughs are ſet to catch the juice. The ſeaſon for tapping is from February to April, for about ſix weeks, during which time a moderate-ſized tree will yield from 20 to 30 gallons of ſap, from which may be made about 5 or 6 lbs. of pretty good ſugar. During the reſt of the year the ſap will flow from the wound, but it is too thin and watery to be uſed with advantage for making ſugar. This evacuation does not appear at all to injure the tree, for the ſame proceſs may be repeated every year for a great length of time; and the juice is even more ſaccharine from the trees that have been previouſly wounded, than from the freſh trees.

This juice is clear, pleaſant-taſted, and highly ſaccharine. It is made into ſugar by the farmers in the country, and with a ſimple apparatus. It is uſually clarified with lime and white of egg (or milk) boiled down, grained and clayed, in the manner of the cane juice. Another method occaſionally practiſed is, to reduce the quantity of liquid by freezing, where the ſeaſon will allow of it, which is preferable to entire evaporation and cheaper. The common maple ſugar is clean-looking, and very ſweet, but with a peculiar though not unpleaſant taſte. It may be made into loaf ſugar probably equally well with the muſcovado, but it is chiefly employed in a half purified ſtate, like the common moiſt ſugars. The maple juice will alſo furniſh a pleaſant wine by fermentation and a good vinegar.

The ſaccharine quality of the juice appears to be highly improved by careful cultivation of the tree.

Among the vegetables indigenous to the middle and north of Europe, which are ſenſibly ſaccharine, the beet root is found to exceed them all in the quantity of ſugar which it contains. This was aſcertained by Marggraf,[e] in ſome valuable experiments made with a view of diſcovering ſome native ſugar which might be a ſubſtitute for the foreign ſugar, when the latter is expenſive and beyond the reach of the peaſant.

Two methods were purſued by this accurate chemiſt. One was to dry a given portion of the vegetable, to boil it in rectified alcohol, and then keep the alcoholic ſolution at reſt for a time, by which the ſugar will ſeparate in cryſtalline grains. This mode however is much too expenſive to be purſued in manufacture, but it ſerves as an uſeful indication of the *comparative* proportions of ſugar in different vegetables, though the *actual* quantity obtainable by the uſual mode of manufacture appears to fall far ſhort of what is yielded by treatment with alcohol.

The other method was to imitate in the ſmall way the proceſs performed on the ſugar cane juice, which alſo was attended with a certain degree of ſucceſs. The experiments of this celebrated chemiſt are the following: three roots were ſelected, the white beet, the red beet, and the ſkirret, all of which give evident indications of abounding in ſugar; for when cut in ſlices and dried their taſte is very ſweet, and the microſcope ſhews a number of cryſtalline grains of ſugar diſperſed through their ſubſtance.

Some ſlices of white beet thoroughly dried but not burnt, were powdered coarſely, and 8 oz. of this powder again dried, were put into a bottle with 16 oz. of highly rectified alcohol, and being looſely ſtopped, the liquor was ſlowly brought to boil on a ſand-bath, with frequent ſhaking. The veſſel was then removed, the ſolution filtered, and the powder preſſed ſtrongly to ſqueeze out all the liquor. This clear ſolution was then put into a bottle which was corked, and ſet by in a cool place. A cryſtallized ſalt depoſited gradually in the courſe of ſome weeks, which was hard and tolerably pure ſugar. This was rediſſolved and again cryſtallized in the ſame way, by which a very pure ſugar was obtained. In this way 8 oz. of the white beet root gave half an ounce or $\frac{1}{16}$ of ſugar; 8 oz. of ſkirret root equally dried, gave 3 drams, or about $\frac{1}{21}$ of ſugar; and the ſame quantity of the red beet gave only $2\frac{1}{2}$ drams, or about $\frac{1}{26}$ of ſugar. The ſolution however ſtill contained a quantity of ſugar mixed with the reſinous part of the root, and if it is evaporated to dryneſs, a ſweetiſh uncryſtallized extract remains.

The ſkirret root was then treated in the following manner without alcohol, with a view of extracting the ſugar. A quantity of it was chopped ſmall, bruiſed in a mortar, and the juice expreſſed through a cloth bag, and the pulp was again moiſtened with water and expreſſed to get out all the ſaccharine liquor. The whole liquor was then kept at reſt for 48 hours, in a cool cellar, by which moſt of the feculence ſubſided, and the clear liquor was carefully drawn off. The author lays much ſtreſs on this part of the proceſs, which, if it is not done properly, conſiderably hinders the ſubſequent production of the ſugar. The clear liquor was then heated in a copper pan, clarified with white of egg, and boiled down to the conſiſtence of thick ſyrup, and kept in this ſtate for about ſix months in a warm place, by which it concreted into a ſemi-fluid cryſtalline maſs, compoſed of impure cryſtals of ſugar and a good deal of ſyrup. The whole maſs was then a little warmed, to give the ſyrup a little more fluidity, and poured into a funnel-ſhaped veſſel of tinned iron, with holes at the ſides and bottom, and ſet by in a warm place; by which, after a conſiderable time, the impure uncongealable ſyrup ſlowly filtered to the bottom, leaving the purer ſaccharine part in the form of a brown granular maſs. The latter was then rediſſolved in water, again clarified with white of egg, ſtrained, boiled with a little lime, again ſtrained, and then evaporated to a thick conſiſtence, and ſtirred till cold. A ſugary viſcid maſs ſtill purer than the laſt was thus obtained, which, on being kept for a week in a funnel-ſhaped pot with a ſingle hole at bottom, plugged up, congealed into a grained ſugar equal to good muſcovado, from which a ſyrup ſeparated and dropped through when the plug was withdrawn.

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[d] Dr. Ruſh, Phil. Mag. vol. I.

[e] Mem. de l'Acad. de Berlin, for 1747.

Such is the proceſs of this chemiſt to obtain a ſugar from the ſkirret root, and he proceeded in the ſame manner with the white and red beet root, and with the ſame ſucceſs. He further obſerves, that he raſped the beet roots, being harder than the ſkirret, that the mucilaginous depoſit from the beets was browner and leſs copious than from the ſkirret; the ſugar from the white beet was the moſt abundant and the pureſt, and that from the red beet was the leaſt ſo. The mucilage or ſediment from the ſkirret waſhed with cold water and purified, yielded a very good white farina.

All theſe roots are very watery. The white beet loſes by gentle, but entire, deſiccation, full three quarters of its weight, and the red beet ſeven eighths.

Mr. Achard, of Berlin, a few years ago directed his attention to the extraction of ſugar from the beet in the large way, and his ſucceſs was ſo great that a reward was given to him by the Pruſſian government for his elaborate experiments; which it was hoped would enable the Continent of Europe to ſupply itſelf with ſugar from the produce of its own ſoil, and to be no longer dependent on the Weſt Indies for this eſſential article of food. The experiments were made on a ſufficiently large ſcale, and the ſucceſs was ſuch as to require ſome notice in this place, but as ſeveral years have elapſed ſince theſe trials were made known to the world, without being followed by any general attempts to purſue them, we muſt conclude that the expence and trouble of obtaining ſugar from this ſource are as yet more than the coſt will repay, eſpecially during the preſent comparatively low price of Weſt India produce.

The plant which yields this ſugar is the *white beet*, the root of which reſembles the parſnip in ſhape, and is white croſſed with bands of red, and has a mild ſweetiſh taſte. It is remarkably ſucculent, and the ſaccharine quality of the juice ſeems to be much improved by careful cultivation in a rich ſoil. It has long been cultivated in many parts of Germany as food for cattle.

The proceſs given by Achard for extracting the ſugar is the following.[f] The roots are pulled, cleaned, the leaves ſtripped off, and then boiled for a ſhort time, till they are ſo far ſoftened that a ſtraw may be thruſt into them. They are then ſliced by a machine uſed in the country for ſlicing potatoes, and put under a very ſtrong preſs to extract the juice. The cake which remains in the preſs ſtill retains enough juice to make it worth while to moiſten it with water and after ſome hours again to preſs it; this juice is mixed with the former. Even after this ſecond preſſing the cake may be uſefully employed in making a fermented liquor, from which a ſpirit may be extracted by diſtillation.

The juice is then ſtrained through a flannel, boiled down to two-thirds of its original bulk, again ſtrained through a thick blanket, and then boiled down to half its bulk, and ſtrained. It is now of the conſiſtence of a thin ſyrup, and muſt be put in ſhallow pans in a ſtove-room, heated to about 120°, to allow the ſugar to cryſtallize. This begins by the formation of a hard cruſt on the ſurface, which muſt be now and then broken down to haſten the evaporation. After a time there forms on the ſurface a thick gummy ſkin, inſtead of a hard granular cruſt; when this appears, the ſyrup is removed from the ſtove-room, and the whole maſs is put into a cloſe linen ſack previouſly wetted, and ſtrongly, but gradually preſſed. By this the ſyrup is forced through the ſack, and there remains within it a yellow granular ſaccharine maſs, reſembling muſcovado ſugar, very ſweet and well taſted. From this, ſugar of any degree of fineneſs may be afterwards made by the proceſſes commonly employed in the refining of cane ſugar.

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[f] An. Chem. tom. 32.

Such is the proceſs of Mr. Achard, which was repeated by a commiſſion from the French Inſtitute,[g] with ſimilar reſults as to the general products, but the quantity yielded was much leſs than what might be inferred from the price which Mr. Achard gives as the firſt coſt to the manufacturer.

According to theſe ſubſequent experiments, purſued preciſely in Mr. Achard's method, 1152 parts of the freſh beet root yielded 18 parts of raw muſcovado, which was brown and ill taſted, and would require ſucceſſive purifications, with the loſs of from $\frac{1}{3}$ to nearly $\frac{1}{2}$ its weight, to bring it to the ſtate of fine ſaleable ſugar.

It ſhould be mentioned that the uncryſtallized ſyrup and all the refuſe, afford excellent materials for fermentation, and hence for the production of ardent ſpirit, or a kind of rum.

Experiments on the extraction of ſugar from the white beet have alſo been made in the large way by Profeſſor Lampadius of Freyberg, the reſults of which are repreſented as very favourable to the undertaker. As the proceſs employed ſomewhat differs from that of Mr. Achard, we ſhall give it in a few words.[h][i] He took 100 lbs. of freſh beet roots, peeled, raſped, and expreſſed them, and obtained 44 lbs. of juice. This he put into a boiler, and added to it 44 oz. of broken charcoal, previouſly made red-hot in the fire, and ſifted when cold to ſeparate and reject the fine powder. This he boiled for a quarter of an hour and ſtrained the juice through flannel, and again returned the clear juice into the veſſel and boiled it down to the conſiſtence of ſyrup. This was ſet by in a cool place for a fortnight, during which it granulated, and the whole was ſtrongly preſſed through a cloth to ſeparate the ſyrup from the congealed ſugar. The latter was then rediſſolved in hot water, ſcummed while boiling, clarified by lime-water and blood, and again ſet by for 48 hours to granulate. The cryſtals were now larger and of a better colour than before, and were again boiled with lime-water and a pint of ſkimmed milk, and cooled as before, by which a blueiſh ſaccharine maſs was obtained, which, when congealed in a mould, gave a loaf of tolerable ſugar weighing 4 lbs. the taſte of which was preciſely the ſame as that of common ſugar of equal fineneſs.

In another experiment conducted in a ſimilar manner only $3\frac{1}{2}$ lbs. of ſugar was obtained.

On repeating theſe experiments in the large way, with ſeveral improvements in the apparatus and proceſs, he obtained (as he aſſerts) from 100 quintals of beet root, 200 lbs. of brown ſugar, which, purified to a conſiderable degree, were reduced to 180 lbs. This proportion is much inferior to that of the former experiments.

The uſe of the charcoal is to deſtroy a quantity of colouring matter, and alſo a bitter unpleaſant taſte which the beet contains. The power of recently heated charcoal in clarifying ſaccharine liquors, and depriving them of all foreign colour, ſmell, and taſte, has been already mentioned in this work under the article *Charcoal*, p. 238, to which it may be added that attempts have been made to introduce it into the ſugar refineries in this country, but whether from the expence and bulkineſs of the charcoal, or from the difficulty of perſuading workmen to alter their accuſtomed habits, the plan has never been carried into practice. In experiments in the ſmall way the clarifying power of charcoal is very ſtriking and eaſily ſhewn, for if a funnel lined with filtering paper, is filled with freſh-burnt charcoal bruiſed to a pretty fine powder, and a ſolution of the coarſeſt brown ſugar be poured on it, as it drops through the funnel it appears fine, limpid, and nearly colourleſs. The ſame effect is produced more rapidly by boiling the ſyrup with the charcoal for a few minutes and ſtraining.

Profeſſor Lampadius alſo ſuggeſts the advantage of reducing the bulk of the ſaccharine juice by freezing, which if not urged too far, will ſeparate much of the watery part in the form of ice, ſo that leſs fuel will be required in the evaporation.

This chemiſt however candidly confeſſes that in one experiment made on 100 quintals of the root, the ſugar obtained ſold for ſomewhat leſs than the entire coſt of the materials and the proceſs, but this was in a cold unfavourable year, and did not include the profits to be made from all the reſidues in yielding ardent ſpirit, &c.

Phyſical and Chemical Properties of Sugar.

Pure ſugar appears either in a regularly cryſtallized form, or in ſhining white cryſtalline grains. Both in candy and in loaf it is very hard and brittle. It is void of ſmell, and its taſte is that of pure ſweetneſs. When hard loaf ſugar is rubbed in the dark it is highly luminous.

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[g] An. Chem. tom. 35.

[h] Journ de Phyſ. tom. 50.

[i] An. Chem. tom. 38.

Sugar is very ſoluble both in water and alcohol. The watery ſolution may be preſerved for a length of time unaltered if the ſugar is pure, but if it is mixed with mucilaginous, farinaceous, or other matters, it readily enters into the vinous fermentation. In this proceſs the ſtrength of the liquor and quantity of alcohol produced, depend directly on the quantity of ſugar preſent, whence the moſt eſſential part of the proceſs of vinous fermentation is reaſonably inferred to be the converſion of ſugar into alcohol. From comparing the products with the materials of fermentation, Lavoiſier concluded that ſugar was a triple compound of 28 parts (by weight) of carbon, 8 parts of hydrogen, and 64 parts of oxygen.

Sugar melts at a heat conſiderably above that of boiling water, and forms a blood-red viſcid fluid, which when cooled has a not ungrateful flavour of empyreuma mixed with the natural ſweetneſs. When melted, it takes fire on applying a lighted ſubſtance, and burns with a ſtrong red flame, and a peculiar and very penetrating odour which excites coughing, and is owing to the production of an acid.

If ſugar is diſtilled *per ſe* from a glaſs retort with a heat gradually increaſed to redneſs, and the products carefully collected, they will be found to be, firſt a coloured liquor ſtrongly acid and pungent, which is called the *Pyromucous*, being the ſame as is furniſhed by mucilage under a ſimilar treatment. A large quantity of gas comes over at the ſame time, which is hydro-carbonat mixed with a little carbonic acid, and a very pure charcoal is left behind, which burns away in the open air without leaving any reſidue.[a] Neither azot, ammonia, nor lime, or any other ſubſtance, is obtained in this proceſs; ſo that ſugar is one of the pureſt hydro-carbonous oxyds that we know.

Under the article *Mucilage* we have mentioned in part the very intereſting reſearches on the comparative nature of ſugar and gum or mucilage, carried on by the laſt mentioned eminent chemiſt. It was there mentioned that ſugar by being treated with phoſphuret of lime (a diſoxygenating ſubſtance) loſt its ſaccharine nature, and was converted into a clammy ſubſtance no longer ſoluble in alcohol, which ſtrongly reſembled mucilage. The converſe of this experiment however, (that is of converting mucilage into ſugar by an oxygenating ſubſtance) would not anſwer, for when nitric and oxymuriatic acid were paſſed through a ſolution of gum-arabic in various ways, nothing ſaccharine could be obſerved, but the whole was converted into the oxalic and other acids.

The actual chemical differences between mucilage and ſugar, as found by Mr. Cruikſhank, are the following: ſugar is ſoluble both in water and alcohol, and cryſtallizable from either ſolution; but mucilage is inſoluble in alcohol, and refuſes to cryſtallize from its watery ſolution. 480 grs. of ſugar yielded by diſtillation 120 grs. of charcoal, 270 grs. of liquid pyromucous acid, 41 oz. meaſures of carbonic acid gas, and 119 oz. meaſures of hydro-carbonat gas:—the ſame quantity of gum arabic yielded 96 grs. of charcoal, 210 grs. of pyromucous acid, 93 meaſures of carbonic acid, and 180 of hydro-carbonat. It alſo gave about 10 grs. of lime, and the acid when ſaturated with lime gave out a little ammonia, and hence lime and azot are ſubſtances that belong to mucilage and not to ſugar.

The habitudes of each ſubſtance with nitric acid alſo differ conſiderably, as already mentioned in part under the article Mucilage. When gum-arabic (for example) is heated with nitrous acid only till nitrous gas begins to be diſengaged, a quantity of white inſoluble matter precipitates which is the *Mucous* acid, and the reſidue is malic acid which a further addition of the nitric converts into oxalic. But ſugar is changed into oxalic, or malic and oxalic acid, without the production of any mucous acid. The quantity of oxalic acid produced from a given weight of ſugar with nitric acid alſo exceeds that yielded by the ſame weight of mucilage with the ſame proportion of acid.

In the ſpontaneous changes alſo ſugar and mucilage differ eſſentially. Sugar being the eſſential material of the vinous fermentation, but mucilage is incapable of this proceſs when pure, and appears to contribute little to the generation of alcohol when in combination with fermenting materials.

SUGAR, *Acid of.* See Oxalic Acid.

SUGAR, *Empyreumatic Acid of.* See Sugar and Pyromucous Acid.

SUGAR OF LEAD. See Lead.

SUGAR OF MILK. See Milk.

SULPHUR, *Brimſtone. Soufre*, Fr. *Schwefel*, Germ.

Sulphur is found both in the mineral, vegetable, and animal kingdoms; in the two latter however it occurs ſo rarely that all the vaſt commercial demands for this ſubſtance are ſupplied from the former ſource. Of mineral ſulphur there are two great families, firſt, *native ſulphur*, or uncombined with any conſiderable proportion of other ingredients. Secondly, ſulphur in union with metallic baſes, forming the various *pyrites and ſulphurated ores*. Of theſe, the latter are deſcribed under the various metals from which they derive their ſpecific characters; the former we ſhall now proceed to give an account of.[a]

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[a] Cruikſhank in Rollo's Eſſay on Diabetes.

The colour of native ſulphur is a pale ſlightly greeniſh yellow, paſſing on one hand into grey, and on the other into lemon yellow. It occurs in maſs, diſſeminated, in rounded fragments, cellular, ſtalactitic, ſuperficial, and cryſtallized. Its primitive form is a very acute octohedron compoſed of two tetrahedral pyramids with ſcalene triangular faces joined baſe to baſe; the common baſe of the two pyramids is a rhomb, the two diagonals of which are to each other in the proportion of five to four. The other varieties of cryſtallization that it preſents, are the following.

1. The primitive figure with the ſummits truncated.
2. The ſame as the preceeding with a low tetrahedral pyramid ſet upon the terminal truncatures.
3. The primitive figure with two oppoſite ſolid angles of the common baſe truncated.
4. The primitive figure with a tetrahedral priſm interpoſed between the pyramids.
5. A cuneiform octohedron.
6. A cuneiform hexahedron.

The cryſtals are generally ſmall and ill defined, but thoſe from Sicily are for the moſt part perfect, and are ſometimes full five inches in length. They are generally grouped together. The cryſtals externally are very brilliant, with a luſtre between reſinous and adamantine; the other varieties are more or leſs gliſtening. Its fracture is fine-grained uneven, paſſing on the one hand to conchoidal, and on the other to ſplintery. The cryſtals are often ſemi-tranſparent, the other varieties are more or leſs tranſlucent. It is ſoft, brittle, and eaſily frangible. Sp. gr. 1.99—2.03.

Sulphur by friction acquires the reſinous electricity; the tranſparent cryſtals are in a high degree double-refractive.

Sulphur is found ſometimes, though rarely, in veins in primitive mountains, its common repoſitory is in beds of ſecondary gypſum, where it occurs principally in nodules; it is ſometimes alſo met with in beds of indurated marl and compact limeſtone. Volcanoes alſo abound in ſulphur, which ſublimes in the rifts and cavities of the lava.

Stratified ſulphur is met with in Sicily, at Conilla near Cadiz in Spain, near Bex in Switzerland, in Lorraine, Hanover, Gallitzia, and Poland: volcanic ſulphur is obtained from Etna in Sicily, the Solfatara near Veſuvius, Hecla in Iceland, the Peak of Teneriffe, the Souffriere in Guadalupe, &c.

The proper native ſulphur ſeldom contains any foreign matter except a ſmall proportion of earth; the whole preparation therefore which it requires for the purpoſes of commerce is to be freed from its earth by diſtillation, and then melted and caſt into moulds.

The ſulphur at the Solfatara is in nodules conſiderably mixed with a white earth; theſe being dug up and broken to ſmall pieces, are put into earthen pots arranged in a double row along a very ſimple furnace; the hole in the upper part of each pot by which it is charged is cloſed with an earthen pipe, and a little lute: and on the application of a gentle heat the ſulphur is volatilized, and paſſes through the pipe into an earthen receiver where it concretes; the contents of the receivers are then melted in a cauldron, the impurities either riſe to the top where they are ſcummed off, or ſubſide to the bottom; and the ſulphur thus purified is run into moulds.

In England a large quantity of ſulphur is obtained at a ſmall expence from the pyritical copper ore during the roaſting which this undergoes previous to the proceſs of ſmelting. At the celebrated Parys mine in Angleſey, works for this purpoſe are conſtructed on a large ſcale. At the foot of a low but ſteep ridge of rock, are conſtructed maſſes of maſonry not unlike high blaſt furnaces, except that the top is capped with a dome of brickwork, from which proceeds a horizontal flue, about the ſize of a common chimney, which terminates in a ſquare or oblong brick chamber, built at the top of the rock. Some lighted fuel is introduced by means of a door in the dome of this roaſting furnace, and a few baſketfuls of ore, broken into moderately ſmall pieces, are thrown on it, freſh parcels of ore being added from time to time as the preceding parcels get lighted; a ſufficiency of air for the ſlow combuſtion required in this proceſs, is let in by means of a door at the bottom of the kiln, which alſo ſerves to take out the ore by when properly roaſted; that part of the ſulphur which eſcapes combuſtion riſes in vapour, and collects in the dome (the door of which is only opened to admit freſh charges of ore) whence it paſſes through the flue into the chamber, where it preſently concretes, lining the ſides and roof; each chamber has a door by means of which, about once in ſix weeks, it is cleared of the ſulphur. This rough ſulphur is in ſpungy pulverulent cruſts, of a dirty greyiſh yellow colour. For its purification it is melted in a boiler, the impurities are got rid of by ſcumming and ſubſidence, and the fluid maſs is then laded into cylindrical moulds to form the common roll ſulphur or brimſtone, or into cones about two feet high forming the loaves of ſulphur. The impure dregs are alſo ſold in the ſhops under the name of *ſulphur vivum.*

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[a] Hauy, Brochant, Jameſon.

Beſides the common ſulphur there are two other forms in which this ſubſtance appears in commerce, namely, the ſublimed, or *flowers of ſulphur*; and the precipitated, or *magiſtery of ſulphur.*

Flowers of ſulphur are prepared in the laboratory, by heating in a ſand-bath an earthen cucurbit charged with roll ſulphur, and ſurmounted by a ſet of aludels; at a gentle heat the ſulphur firſt melts, then riſes in vapour, and concretes within the aludels in the form of a glittering yellow powder, which when examined by a microſcope appears to be compoſed of minute cryſtals. Flowers of ſulphur are made in the large way by conducting the vapour of melted ſulphur into cloſe chambers inſtead of aludels, and being prepared with leſs care it is often inferior in purity to that obtained by the former method. Flowers of ſulphur, however prepared, are more or leſs acidulous from a mixture of ſulphureous acid, on which account an infuſion of them in water, reddens tincture of litmus; this acid, however, may eaſily be got rid of by waſhing the powder firſt with a warm and very dilute ſolution of pearl-aſh, and then with two or three ſucceſſive parcels of warm water.

Magiſtery of ſulphur is prepared by decompoſing by the ſulphuric or any other acid a ſolution of alkaline ſulphuret; a copious white precipitate falls down, which is to be thoroughly edulcorated with ſucceſſive portions of warm water. Sulphur in this ſtate has a dull earthy appearance, owing to its extremely minute ſtate of diviſion; it is of a yellowiſh white colour, is ſmooth and almoſt unctuous to the touch; by expoſure to light it acquires a yellow colour. It is generally looked upon as the pureſt form of ſulphur, yet from ſome of its properties and the mode in which it is prepared, there is ſome reaſon for ſuſpecting that a portion of hydrogen enters into its compoſition.

The ſulphur that is procured in the roaſting of ores, eſpecially thoſe of copper, is apt to contain beſides earthy impurities a very notable proportion of arſenic, while on the other hand the volcanic ſulphur in general, and that of Sicily in particular, is entirely free from this contamination. This is the cauſe of the univerſal preference given by the manufacturers of ſulphuric acid to Sicilian, over Engliſh ſulphur; and hence it is a matter of ſome conſequence to be able to aſcertain in a compendious and ſatisfactory manner the purity of any particular ſample of this ſubſtance. The following method will, we believe, be found to anſwer every practical purpoſe. Having rubbed to fine powder in an earthen-ware mortar ſome of the ſulphur to be examined, take 100 grs. and put it into a Florence flaſk with 5 oz. meaſures of the *beſt* oil of turpentine; heat the mixture gently over a lamp, or a pan of charcoal, till it has boiled for about a minute, then pour the clear hot ſolution into a ſix or eight-ounce vial, ſtop it with a cork, and ſhake it till the liquor has cooled down to the temperature of the hand; it will now be quite turbid with ſulphur that has ſeparated from the oil during its cooling, and being run through a glaſs funnel very lightly plugged with fine tow will paſs out clear, leaving the ſulphur behind. The oil is now to be again transferred to the ſulphur remaining in the flaſk, and to be a ſecond time boiled, cooled and filtered as before. By repeating this proceſs four or five times, there will be left only a browniſh orange reſidue, on which the oil will refuſe to act any longer. This reſidue being laid on a piece of earthen ware is to be expoſed to a heat not higher than that of melting lead, till it ceaſes to exhale any ſulphureous vapours; being then rubbed up with a little moiſtened charcoal, and preſſed into the bowl of a tobacco-pipe or any other convenient veſſel, it is to be heated nearly red, upon which a white vapour will ariſe, and ſhow itſelf to be arſenic by its peculiar garlic odour. The ſulphur precipitated from the oil of turpentine may be entirely freed from this latter by expoſure to the air and light for a day or two; it will then be of a beautiful ſparkling yellow colour (far ſuperior to that of the common flowers of ſulphur) and entirely inodorous. The common Engliſh brimſtone or roll ſulphur ſometimes contains a full $\frac{1}{15}$ of inſoluble reſidue, chiefly orpiment; the beſt Sicilian ſulphur in ſmall rolls, contains hardly more than 3 per cent. of reſidue which appears to be little elſe than earth, as it affords no arſenical odour when heated with charcoal.

To the taſte ſulphur is perfectly inſipid, when broken down however by the teeth, it manifeſts a peculiar indeſcribable grittineſs, which ſufficiently diſtinguiſhes it from all other bodies. It is inodorous at the common temperature, but when rubbed a ſlight fetid ſmell is ſufficiently perceivable; if a roll of ſulphur is held for a minute in a moiſt warm hand, it breaks acroſs with a ſharp crackling not unlike the ſnapping from the diſcharge of an electrical ſpark, the hand at the ſame time contracts a peculiar diſagreeable odour, which laſts ſome minutes. When expoſed to a temperature of about 224° Fahr. it melts into a tranſparent browniſh red fluid; by an increaſe of heat, the fluidity diminiſhes and the ſulphur begins to ſublime in viſible vapours; when it ſomewhat exceeds the temperature of 300° Fahr. its conſiſtence will be viſcid and thick like treacle, and the vapour will take fire, the inflammation inſtantly ſpreading to the reſt of the maſs.

If a crucible or ladle full of ſulphur be allowed to cool gradually, and the fluid central part be let out juſt before it ſolidifies, by piercing the outer cruſt, the cavity will be found to be entirely lined with compreſſed needle-ſhaped cryſtals. When ſulphur has become viſcid by heat its fluidity may be reſtored merely by lowering its temperature; if it is kept in this thick ſtate for a few minutes, and then without previous cooling is poured into warm water, it will be of a brown colour, ſoft and conſiderably plaſtic; in this ſtate it is a very uſeful material to artiſts and modellers for taking impreſſions of ſeals, gems, &c. eſpecially as in the courſe of a few hours it reſumes the hardneſs and other properties of common ſulphur. This ſoft ſulphur is conſidered by Fourcroy (but we think without ſufficient proof) to be an oxyd of ſulphur.

Water in the ſtate of ſteam is partly decompoſable by melted ſulphur, an inflammable gas, perhaps ſulphuretted hydrogen, being produced. With oxygen, ſulphur combines in two proportions; if this latter is heated in common air till it becomes thick, it takes fire, burns with a blue flame, and is converted into a pungent highly ſuffocating acid gas called Sulphureous Acid; if on the other hand it is ſet fire to in oxygen gas, the flame which it emits is of a reddiſh purple colour, and the acid produced is Sulphuric mixed with ſulphureous.

The chief acids that have any action on ſulphur are the nitric, oxymuriatic, and ſulphuric. The former is decompoſed upon ſulphur at a boiling heat, nitrous gas is given out, and ſulphuric acid is the reſult. The ſecond in like manner acidifies the ſulphur, but with ſome peculiar phenomena deſcribed under the article Sulphurized Muriatic Acid. Sulphuric acid with ſome difficulty takes up a ſmall proportion of ſulphur, and ſulphureous acid is produced, partly from the oxygenation of the ſulphur, and partly from the deoxygenation of the ſulphuric acid.

The alkalies and alkaline earths combine with ſulphur forming the important claſs of *Alkaline* Sulphurets. Moſt of the metals and metallic oxyds alſo combine with ſulphur and produce the claſs of *Metallic* Sulphurets. Sulphur unites with hydrogen, forming Hepatic gas or Sulphuretted Hydrogen. The combinations of ſulphur with carbon and with phoſphorus, have been already deſcribed under thoſe articles.

Sulphur when in fine powder is ſparingly ſoluble by digeſtion in highly rectified alcohol, but a more concentrated ſolution is made by preſenting each to the other in the ſtate of gas; for this purpoſe put ſome ſulphur into a cucurbit, and ſuſpend within the ſame a vial filled with alcohol, then lute on a head and proper apparatus, and proceed to diſtillation; both the ſulphur and alcohol are volatilized, and meeting with each other in the upper part of the veſſel combine readily together, and condenſe in the receiver into a yellowiſh ſtrongly ſmelling fluid, from which nearly the whole of the ſulphur may be again precipitated by the addition of water.

Oil of turpentine and the other eſſential oils diſſolve a conſiderable proportion of ſulphur when hot, the greateſt part of which they again depoſit in cryſtals if cooled ſlowly. The fat oils unite with ſulphur by boiling, and acquire a deep yellowiſh brown colour, and a ſtrong fetid odour; the combination is generally called *balſam of ſulphur*. By long repoſe in a cool place, it depoſits ſmall octohedral cryſtals of ſulphur.

The order of affinities for this ſubſtance, according to Bergman is, fixed alkali, iron, copper, tin, lead, ſilver, biſmuth, antimony, mercury, arſenic, and molybdena.

The uſes of ſulphur are very important. It is employed in medicine; it enters into the compoſition of ſulphuric acid, of gunpowder, and of the common compoſition for paying the bottoms of ſhips. Its fumes when burning, are employed for bleaching ſilk and wool, and checking the progreſs of vinous fermentation. Common matches which are in daily uſe for lighting fires derive their principal utility from being tipped with ſulphur.

SULPHUR, *golden, of Antimony.* See ANTIMONY.

SULPHURET.
SULPHURETTED HYDROGEN.
HYDROSULPHURETS, &c.

The various combinations of ſulphur with alkaline, earthy, and metallic baſes, of ſulphur with hydrogen, and the latter compound with the ſeveral baſes in different proportions of ſulphuration, are ſo intimately connected with each other in chemical enquiry, that we have preferred to give the whole under one article, eſpecially as the ſubject is ſomewhat intricate, and requires ſome attention to be fully underſtood.

The ſeveral combinations which belong to this ſubject, are

1. *Sulphuretted Hydrogen,* compoſed of hydrogen holding ſulphur in ſolution, and when uncombined with a baſe aſſuming the gaſſeous form.
2. The *Hydroſulphurets,* or combinations of ſulphuretted hydrogen with the ſeveral alkaline, earthy, and metallic baſes, in which its action ſtrongly reſembles that of an acid.
3. The *Sulphurets,* or combinations of ſulphur with the alkalies, earths, and metals.
4. *Superſulphuretted Hydrogen,* or ſulphuretted hydrogen, with a conſiderable, but, in general, an uniform exceſs of ſulphur.
5. *Sulphuretted Hydro-ſulphurets,* or combinations of ſulphur, ſulphuretted hydrogen, and the alkaline or earthy baſes.

SULPHURETTED HYDROGEN GAS, or *Hepatic Air. Gas Hidrogene Sulfuré* of Berthollet, and other French chemiſts. *Hydrothionic Acid* of ſome German authors.

The properties of this gas were firſt explained in a very excellent memoir by Mr. Kirwan,[a] and nearly at the ſame time by M. Gengembre,[b] and the ſociety of Dutch chemiſts, and ſince this period they have been ſtill more fully unfolded by Berthollet, Fourcroy, Prouſt, and other eminent chemiſts. The moſt ſtriking and obvious properties of this gas are the following: it has a moſt penetrating and offenſive ſulphureous ſmell, ſimilar to that of rotten eggs, or a foul gun-barrel when wetted, but ſomewhat leſs nauſeous; it is rather heavier than common air; it is inflammable, and explodes like hydrogen, only with leſs violence, when mixed with common air or oxygen; when moderately diluted it may be breathed for a ſhort time without danger; it is abſorbed readily by water to a certain extent, and then it reddens litmus, and has a ſweetiſh but very nauſeous taſte; it ſpeedily blackens ſome of the white metals, and all their ſolutions, particularly lead, ſilver, and mercury, and precipitates ſeveral metals from their ſolutions; and laſtly it combines copiouſly with the alkaline, earthy, and metallic baſes, ſaturating them like an acid.

This gas is procured in greateſt abundance by means of the ſolid ſulphurets, either of the alkalies or of iron, and an acid. For this purpoſe put ſome pieces of the ſulphuret of potaſh (for example) made by melting together equal parts of ſulphur and common carbonat of potaſh, into a proof bottle, and add ſulphuric or muriatic acid moderately dilute. An efferveſcence will enſue, attended with an intenſely fetid ſmell, and the ſulphuretted hydrogen gas riſes in abundance. It may be collected either over water or mercury; if the former, part of it is abſorbed by the water; if the latter, the mercury is a good deal blackened at the ſurface. This gas when obtained from the alkaline ſulphuret, unleſs a cauſtic alkali be uſed, is however mixed with carbonic acid, and therefore this ſulphuret is not ſo good a material as the *ſub ſulphuret* of iron, or that in which the ſulphur is in much ſmaller proportion to the iron than in the common native ſulphuret or pyrites. The difference between theſe ſulphurets has already been fully explained under the article IRON, *(Vol. I. p. 623 & ſeq.)* and a maſs very convenient for yielding the gas may be prepared by half-filling a crucible with common iron pyrites, covering it with a third or half its weight of iron filings, over this preſſing a little charcoal powder, and heating the whole moderately red-hot for a quarter of an hour. It is not neceſſary to urge the heat to the fuſion of the materials. The pyrites and iron filings may alſo be previouſly mixed and treated as above. This gives a black brittle uniform maſs that yields abundance of the gas with muriatic or dilute ſulphuric acid. A mixture of three parts of iron-filings and one of ſulphur ſimply melted together in a covered crucible, anſwers as well as the pyrites and iron filings.

Sulphuretted hydrogen when pure is heavier than common air (according to Kirwan) in the proportion of 10000 to 9038, ſo that 100 cubic inches of it weigh about 33 grains. When mixed with its own bulk of common air and kindled, it takes fire and burns with a blue flame without detonation. During the combuſtion ſulphur is conſtantly depoſited, and a ſulphureous ſmell is perceived. When previouſly mixed with oxygen and kindled, it explodes with ſome violence, though leſs in degree than an equal quantity of hydrogen in ſimilar circumſtances. A mixture of equal parts of ſulphuretted hydrogen and nitrous gas burns with a greeniſh-yellow lambent flame, and ſulphur is depoſited. According to Sennebier this gas mixed with common air cannot be kindled by the electric ſpark.

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[a] Phil. Trans. for 1786.

[b] Journ. de Phyſique for 1785.

This gas is diſtinguiſhed by the depoſition of all or part of its ſulphur whenever it is decompoſed, whether by combuſtion or acids, or in any other way; for as it conſiſts ſimply of hydrogen holding a quantity of ſulphur in ſolution, and as in all theſe decompoſitions the hydrogen is the ſubſtance firſt acted on by the decompoſing ſubſtances, at the inſtant of decompoſition it quits its ſulphur before the latter has an opportunity of undergoing its peculiar changes. Thus in the combuſtion of this gas with a large portion of common air, the hydrogen unites with part of the oxygen of the air, and produces water, and at the ſame inſtant part of the ſulphur undergoes combuſtion with another portion of the oxygen, and produces ſulphureous acid, as is obvious to the ſmell, but the reſt of the ſulphur is precipitated in its natural form.

Sulphuretted hydrogen is readily abſorbed by water, and in conſiderable quantity. Mr. Kirwan eſtimates that at a moderate temperature water will take up about three fourths of its bulk of the gas as procured from ſulphuret of iron, and by long continued agitation it may be made to abſorb as much as twice its bulk. The whole is again expelled at a boiling heat. Hydro-ſulphuretted water has a ſweetiſh nauſeous taſte, and a very ſtrong fetid ſmell, but the diſguſt excited at firſt taſting it, goes off very ſoon when daily uſed, as it is medicinally. This combination is found native in many ſprings, all the cold ſulphureous mineral waters, ſuch as thoſe of Harrowgate, Moffat, &c. being natural ſolutions of ſulphuretted hydrogen in water. A much ſmaller quantity of the gas than can be artificially condenſed in water is ſufficient to render water moſt powerfully ſulphureous to the taſte and ſmell, for the Harrowgate, which is ſo celebrated, contains no more than about $\frac{1}{12}$ of its bulk of the gas. Hydro-ſulphuretted water if expoſed to the air for a ſhort time grows turbid, and the ſulphur is ſlowly depoſited on the ſides of the veſſel in the form of a thin yellow film. A ſimilar decompoſition takes place, though in a longer time, even when kept in a cloſe veſſel. The water after this loſes its peculiar ſcent. Hence in uſing theſe waters medicinally it is neceſſary to drink them at the ſpring head, or very ſoon after being drawn.

Hydro-ſulphuretted water reddens the infuſion of litmus, which ſeems to ſhew ſome acid property. On adding a few drops of ſulphureous, nitric, or oxymuriatic acid to the water, ſulphur is immediately depoſited, which is the only way of extracting the ſulphur from it in ſubſtance. Theſe acids ſeparate the ſulphur by combining with the hydrogen. But if a great exceſs of oxymuriatic acid is uſed, the ſulphur itſelf becomes oxydated, and converted into ſulphuric acid, ſo that the liquor becomes again tranſparent, and the newly generated ſulphuric acid may be precipitated, and its quantity (and conſequently that of the ſulphur) eſtimated by a barytic ſolution. Hydro-ſulphuretted water does not affect lime-water till after ſtanding for ſome time, and then the precipitate is ſulphur and not lime, and hence is not rediſſolved by weak muriatic or any other acid. This forms a deciſive teſt to diſtinguiſh this gas from carbonic acid or any admixture of the two. This water or any other ſolution of ſulphuretted hydrogen alſo immediately blackens the ſolutions of lead, ſilver, and biſmuth, and produces other peculiar effects on metallic ſalts, which will be preſently mentioned.

The following effects were produced by the mixture of this with the other gaſſes,[c] the experiments being performed *over mercury*.

Equal parts of ſulphuretted hydrogen and common air mixed together remained unaltered for ſeveral days, with a diminution of only $\frac{1}{120}$ in bulk, and a blackening of the ſurface of the mercury. The ſame took place when pure oxygen gas was ſubſtituted to common air, and after eight days the mixture exploded when fired. Very little action therefore takes place between theſe gaſſes unleſs water be preſent.

Equal parts of ſulphuretted hydrogen and muriatic acid gas remained unaltered, and the mercury was not blackened.

No action enſued on mixing this gas with carbonic acid gas.

On adding five cubic inches of ſulphureous acid gas to one of ſulphuretted hydrogen, in leſs than a minute, without agitation, the ſides of the glaſs were covered with a whitiſh ſcum which ſeemed moiſt, and a diminution of one cubic inch took place. Six more cubic inches of ſulphuretted hydrogen were added ſucceſſively, a diminution took place after each, ſo that at laſt 11 inches, (namely 5 of ſulphureous acid gas, and 6 of ſulphuretted hydrogen) were reduced to 3 inches, part of which was ſoluble in water, and the remainder was azot. The jar was coated with ſulphur in the proceſs, and when rinced out, the water uſed for the purpoſe gave a white precipitate with the ſolutions of barytes, ſilver, and lead, and lime-water, and contained both carbonic and ſulphuric acids. The colour of the precipitates of the above metallic ſolutions proved that all the ſulphur in the ſulphuretted hydrogen had been ſeparated before the water was admitted to the reſidual gas. The mutual actions that take place between all theſe ſubſtances muſt be very complicated. On the one hand ſulphur diſſolved in hydrogen is mixed with a gaſſeous combination of ſulphur not ſaturated with oxygen, and the products are, much ſulphur in ſubſtance, water and ſulphuric acid, or ſulphur *ſaturated* with oxygen, (the carbonic acid and azot being put out of the queſtion, as being probably accidental impurities) and withal there is a great diminution in the bulk of the gaſſes. Therefore we muſt ſuppoſe that the hydrogen of the ſulphuretted hydrogen unites with part of the oxygen of the ſulphureous acid gas to produce water, and thereby depoſits in ſubſtance the ſulphur with which it was combined; and on the other hand the ſulphureous acid being deprived of part of its oxygen, depoſits much of its ſulphur in ſubſtance, whilſt the remainder of its oxygen condenſes itſelf into another part of the ſulphur and produces ſulphuric acid. According to this explanation therefore, both the gaſſes contribute to the formation of the ſulphur, and certain it is that the quantity of ſulphur is much too great to ariſe ſolely from the ſulphuretted hydrogen.

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[c] Kirwan.

When 8 cubic inches of ſulphuretted hydrogen were mixed with 9 inches of nitrous gas, a yellowiſh cloud appeared, together with a ſudden abſorption, which gradually increaſed, till after 48 hours the whole was reduced to 6 cubic inches, and the top and ſides of the jar were covered with a white cake of ſulphur. The reſidual air appeared to be nitrous oxyd. The theory of this decompoſition is obvious, and much ſimpler than the laſt, the hydrogen of the ſulphuretted hydrogen uniting with part of the oxygen of the nitrous gas, leaving the remainder in the form of nitrous oxyd, and the ſulphur being depoſited unchanged.

Sulphuretted hydrogen and ammoniacal gas appear to combine totally if the ingredients are pure and in proper proportions. On adding 6 cubic inches of the former to 7 of the latter gas a ſmall white ſcum appeared, but in a few ſeconds the whole was reduced to $\frac{6}{7}$ of an inch, and on throwing up water only $\frac{1}{7}$ of an inch remained. The water thus impregnated is a ſolution of hydro-ſulphuret of ammonia, and, as appears, no decompoſition takes place, for ſcarcely any ſulphur is depoſited. This combination will be afterwards mentioned more at large.

Sulphuric acid abſorbs ſulphuretted hydrogen. One meaſure of the acid, of 1.863 ſp. gr. was found by Mr. Kirwan to take up nearly 2 meaſures of the gas over mercury, and the acid was whitened with a copious depoſition of ſulphur.

Concentrated nitrous acid abſorbs part of the air and ſeparates ſulphur, but it is extremely difficult to contrive an unexceptionable mode of making the experiment, for the acid acts upon mercury, and if water is uſed, it dilutes the acid ſo much that it no longer has the power of decompoſing the gas and ſeparating the ſulphur.

Alcohol readily abſorbs about thrice its bulk of this gas. Water precipitates a part of the ſulphur from it. Sulphuric ether alſo abſorbs about half its bulk of the gas.

It has been mentioned that the eaſieſt method of procuring ſulphuretted hydrogen, is by adding an acid to the alkaline, earthy, or metallic ſulphurets.

In this caſe, as Gengembre has proved, part of the water of the acid is decompoſed, its hydrogen forms a gaſeous combination with part of the ſulphur preſent, and produces the ſulphuretted hydrogen, whilſt its oxygen unites with another portion of ſulphur, and forms ſulphuric acid, which is always found in the reſidue in exact proportion to the quantity of gas produced.

Sulphuretted hydrogen is alſo formed without any apparent decompoſition of water, being produced in abundance by heating ſtrongly a mixture of ſulphur with any ſubſtance that yields hydrogen. Thus Mr. Kirwan obtained it in large quantity by heating a mixture of two parts of white ſugar (previouſly melted to expel all the moiſture) with one of ſulphur. This gas was very pure and contained neither carbonic nor any other acid. On the other hand a mixture of ſugar and ſulphur moiſtened with muriatic acid gave out no gas, becauſe there was no power applied capable of reſolving the ſugar into hydrogen. Many other methods of obtaining the gas might be ſuggeſted, in which ſulphur ſhould be in contact with hydrogen at the moment of its formation. This gas however is not produced by heating ſulphur in contact with hydrogen gas, nor by paſſing this gas over ſulphur melted, and kept red-hot in a cloſe tube, ſo that it appears neceſſary in all caſes that the hydrogen ſhould be preſented to the ſulphur either in a naſcent ſtate, or condenſed in a ſolid or liquid.

According to Mr. Kirwan, 100 cubic inches of this gas contain about 30 grs. of ſulphur. Whence, ſuppoſing that 100 cubic inches of common air weigh 30.414 grs. (at 60° Th. and 29.5° Bar.) and that this gas is heavier than common air in the proportion of 10000 to 9038, 100 cubic inches of ſulphuretted hydrogen ſhould weigh 33.65 grains, of which 30 grains are ſulphur, and 3.65 grains hydrogen. The quantity of ſulphuretted hydrogen contained in any water, he eſtimates by the quantity of ſulphur precipitated and collected, when a given portion of the water is decompoſed by nitrous gas and common air, as will be more fully deſcribed under the article WATERS (*Mineral*). In this method therefore, and from the above data, 30 grs. of ſulphur would indicate 100 cubic inches of the gas, and therefore one grain of ſulphur is equivalent to $3\frac{1}{3}$ cubic inches of the gas.

The eſtimation made by Thenard, of the compoſition of this gas, does not even approach to that of Kirwan juſt mentioned. Thenard eſtimates the cubic centimetre of the gas to weigh (at a medium preſſure and temperature) 1.513 millegrammes, which reduced to Engliſh meaſure would give the weight of 100 cubic inches at 41.1 grains inſtead of 33.65 as Mr. Kirwan eſtimates it. Mr. Thenard analyſes the gas by cauſing water to abſorb the whole, and then adding oxymuriatic acid ſufficient firſt to precipitate the ſulphur, and then to convert it totally into ſulphuric acid, from the weight of which (as indicated by the quantity of ſulphat of barytes formed on adding muriated barytes) he eſtimates that of the ſulphur entering into its compoſition. From theſe data he concludes that 100 parts, by weight, of the gas are compoſed of 70.857 of ſulphur, and 29.143 of hydrogen, whereas the proportions given by Mr. Kirwan would be (in 100 by weight) about 89.1 of ſulphur, and 10.9 of hydrogen.

Though much of this difference muſt be aſcribed to the different mode of analyſis purſued, part of it may doubtleſs ariſe from occaſional variation in the conſtitution of the gas, for there is no ſatisfactory reaſon for ſuppoſing that the degree of ſulphuration of this gas ſhould be always uniform, any more than the proportion of phoſphorus in the phoſphuretted hydrogen, or of arſenic, in the arſenicated hydrogen, which are known to vary conſiderably.

There is likewiſe ſome difference in the ſulphuretted hydrogen, according to the ſulphuret or other material from which it is procured, independently of any palpable admixture of carbonic acid or other known gaſſes, for that which is procured from the ſulphuret of ſtrontian burns with a *red colour* like the ſalts of this earth, which would ſhew that ſome of the ſtrontian itſelf is volatilized along with the gas.

Metallic Hydro-ſulphurets.

Sulphuretted hydrogen exerciſes a very ſtrong action on ſome metals in ſubſtance, and on many more metallic ſalts. When ſulphuretted hydrogen, either in the gaſſeous form, or diſſolved in water, is added to a metallic ſolution, part of the hydrogen firſt unites with part if not all of the oxygen of the metallic oxyd, and reduces it nearly to the metallic ſtate, and the remainder of the ſulphur and hydrogen unite with the metal, and the whole is generally ſeparated from the acid of the ſolution in the form of a coloured precipitate, which therefore is either a ſulphuret or a hydro-ſulphuret of the metal according to circumſtances. Sometimes too a ſmall portion of ſulphuric acid is formed at the ſame time, which renders the play of affinities ſtill more complex. Some of the metallic ſolutions afford no precipitate with ſulphuretted hydrogen, or at leaſt the precipitate is rediſſolved by a ſlight exceſs of acid, but with other metals it is permanent.

Nitro-muriat of *Gold* is precipitated black by hydro-ſulphuretted water,[a] — nitrat of *Silver*, black, but the precipitate is again ſoluble by agitation if there is a ſenſible exceſs of acid— nitrated *Mercury*, yellowiſh brown, and *Corroſive Sublimate* dark yellow, which becomes black by agitation — ſulphat of *Copper*, black, and nitrat of *Copper* brown — nitro-muriat of *Platina*, reddiſh white—the ſalts of *Lead*, deep black—thoſe of *Zinc*, white—the ſalts of *Biſmuth*, reddiſh brown, paſſing into black—muriat of *Tin*, a dull white.

The metals that are not precipitated from their ſolutions by ſulphuretted hydrogen, are *Iron*, *Cobalt*, *Nickel*, *Manganeſe*, and in ſome caſes *Antimony* and *Arſenic*. Theſe ſolutions however are deeply coloured by the ſulphuret, that of iron becoming black; of antimony, orange; of arſenic, yellow, &c. but either no precipitate forms, or if formed, it is rediſſolved by any exceſs of acid. Thus if ſulphuretted hydrogen is added to a ſolution of the red ſulphat of iron, the metal is immediately brought to the ſtate of the green, or leſs oxygenated ſulphat, but no precipitate is formed unleſs the ſulphuretted hydrogen be in great exceſs, as the red ſulphat has naturally an exceſs of acid. On this principle is founded an uſeful teſt to diſtinguiſh iron from lead in wine or any other liquor, for by adding hydro-ſulphuretted water, and a ſlight exceſs of dilute muriatic, or any other weak acid, if iron only be preſent, the liquor will aſſume a deep red, but will remain tranſparent, whereas lead will give a black muddy ſediment. Often too this teſt is uſeful for ſeparating one metal from another in the ſame ſolution, both where a precipitable and a non-precipitable metal are preſent, and where there are metals more or leſs eaſily precipitable. Thus if manganeſe, zinc, tin, and copper, are in the ſame ſolution, the firſt addition of hydro-ſulphuretted water will ſeparate the tin, after which the copper will fall, and then the zinc, whilſt the manganeſe remains in ſolution.

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[a] Kirwan and Berthollet.

In all the above circumſtances it is the ſimple hydro-ſulphuretted water which is meant, and not the alkaline hydro-ſulphurets, for though the action of the latter is in general very ſimilar to that of the ſimple hydro-ſulphurets there are ſome important differences, and in particular, the alkaline hydro-ſulphurets precipitate *all* the metallic ſolutions without exception, as will be afterwards noticed.

Alkaline and Earthy Hydro-Sulphurets.

Sulphuretted hydrogen unites readily, and in large quantity with the alkalies and alkaline earths, forming tranſparent, colourleſs, often cryſtallizable ſalts, in which the baſe is nearly if not entirely ſaturated, and from which the ſulphuretted hydrogen is expelled in ſtrong effervеſcence by the addition of a ſtronger acid (as the carbonic is from the carbonats) without any other decompoſition or depoſition of ſulphur, unleſs the acids uſed are the nitrous or oxymuriatic which are themſelves decompoſed, and yield oxygen to the ſulphuretted hydrogen.

The hydro-ſulphurets are all ſoluble in water, and the ſolution is at firſt colourleſs, but by expoſure to air it becomes firſt greeniſh yellow and then depoſits ſulphur, and in this ſtate the ſtronger acids cauſe a further precipitation of ſulphur. After a while alſo ſulphureous acid is formed, and may be expelled by a ſtronger acid, but this does not take place till all the ſulphuretted hydrogen is decompoſed. Finally, when the hydro-ſulphuret has been very long expoſed to the air it becomes again entirely colourleſs, and loſes all its ſulphureous ſmell and taſte, and is converted into a ſulphat of the alkali or earth which was originally employed.

Hydro-Sulphuret of Potaſh is formed by paſsing ſulphuretted hydrogen through a ſolution of potaſh till no more will be abſorbed, and expelling the exceſs of ſulphuretted hydrogen by boiling for a few minutes. The ſolution evaporated and cryſtallized gives a perfectly tranſparent colourleſs ſalt in large cryſtals, with an alkaline and very bitter taſte. It deliqueſces in the air, and then has the peculiar fetid ſmell of ſulphuretted hydrogen, but when dry it is ſcentleſs. It diſſolves in water and alcohol, producing cold during ſolution, which is a proof of the complete ſaturation of the alkali. Acids cauſe a lively effervеſcence and expell pure ſulphuretted hydrogen, but no ſulphur is depoſited.

This ſalt may be formed by calcining a mixture of ſulphat of potaſh and charcoal, by which the ſulphat is converted into a ſulphuret, and by lixiviating the ſulphuret with water, and ſaturating this ſolution with ſulphuretted hydrogen by which the exceſs of ſulphur will be depoſited, and a ſimple hydro-ſulphuret of potaſh will remain in ſolution.

Hydro-ſulphuret of Soda. This ſalt is prepared in the ſame manner as the laſt, and reſembles it cloſely in moſt of its chemical properties. It was firſt obtained cryſtallized by Vauquelin, in the following way; a maſs of impure carbonat of ſoda procured by the decompoſition of common ſalt was lixiviated to extract the carbonat of ſoda, and the mother liquor after ſtanding at reſt for a conſiderable time was found filled with a colourleſs tranſparent ſalt cryſtallized in four-ſided priſms, which had an acrid burning taſte ſucceeded by an intenſe bitterneſs, and a ſlight flavour of ſulphuretted hydrogen. This ſalt diſſolves copiouſly in water, producing cold during ſolution, and the liquid has a ſlightly ſulphureous ſmell. Muriatic and ſulphuric acids expell ſulphuretted hydrogen, and do not produce any turbidneſs, but the nitric and oxymuriatic acids, (that is, thoſe which yield oxygen readily) ſeparate an abundance of ſulphur.

The mode of its production in the caſe mentioned by Vauquelin, muſt have been the following; muriat of ſoda was decompoſed in the large way, (probably by gypſum and pyrites) and a proportional quantity of ſulphat of ſoda produced; the latter ſalt was decompoſed by the combination of chalk and charcoal (in the way deſcribed under the article *Muriat of Soda*, *p*. 130) and a quantity of carbonat of ſoda was produced, but probably owing to not employing chalk enough, part of the ſulphat of ſoda eſcaped entire decompoſition, and was converted by the charcoal into a ſulphuret, which by lixiviation became a hydro-ſulphuret, and cryſtalliſed by repoſe.

Hydro-ſulphuret of ſoda is uſefully employed as a chemical teſt to ſeparate certain metals from mixed ſolutions of metals and earths, as the alkaline hydro-ſulphurets will precipitate the former but not the latter, except thoſe of alumine.

Hydro-ſulphuret of Ammonia.. The compleat condenſation of ſulphuretted hydrogen and ammoniacal gas, confined over mercury, has been already mentioned. The reſult is hydro-ſulphuret of ammonia, which however is formed more conveniently by paſſing the gas through liquid ammonia till the latter is ſaturated. This ſolution has a greeniſh yellow colour, and agrees with the other hydro-ſulphurets in the eſſential quality of giving out ſulphuretted hydrogen on the addition of an acid, and of not precipitating any ſulphur in the proceſs. When the ammonia is in exceſs, and the ſolution concentrated, it conſtantly ſends forth white fumes when expoſed to air, which conſiſt of unſaturated ammoniacal gas holding hydro-ſulphuret of ammonia in ſolution. This fuming property was firſt obſerved by Boyle, in the liquor prepared by diſtilling lime, ſal ammoniac, and ſulphur, and which will be afterwards deſcribed under the head of *Sulphuretted hydro-ſulphurets.*

Hydro-ſulphuret of Barytes. This ſalt might doubtleſs be prepared like the other hydro-ſulphurets, ſimply by ſaturating barytic water with ſulphuretted hydrogen; but it is more conveniently obtained, as Berthollet has diſcovered, through the intermedium of the dry ſulphuret of barytes. For this purpoſe mix ſulphat of barytes with about a ſixth of its weight of finely powdered charcoal, and calcine it in a moderate red heat for about half an hour, in a covered earthen crucible. This produces a ſulphuret of barytes which is to be diſſolved to ſaturation in boiling water, and on haſty evaporation and cooling a copious quantity of irregular cryſtals will be formed, which may be ſeparated from the adhering liquor by preſſing them between folds of filtering paper. The ſalt is then white and tranſparent, and is the hydro-ſulphuret of barytes. The ſolution that remains is the ſame ſalt with an exceſs of ſulphur. If the firſt ſolution before the ſeparation of the ſaline cryſtals be decompoſed by carbonated ſoda, carbonat of barytes falls down, and the ſolution contains very pure hydro-ſulphuret of ſoda. If muriatic acid be added inſtead of carbonated ſoda, a moſt copious emiſſion of ſulphuretted hydrogen takes place, and muriated barytes remains in ſolution. The above methods of procuring carbonat and muriat of barytes are very uſeful in the laboratory.

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Sulphuret of barytes gives out a greater quantity of ſulphuretted hydrogen than any other of the ſulphurets, whence the eaſe with which that portion of the earth becomes ſaturated with the ſulphuretted hydrogen, which ſeparates in the cryſtalline form. This is explained by Berthollet from the ſtrong affinity which barytes has with ſulphuric acid, and the conſequent rapidity with which this acid is gegenerated. Hydro-ſulphuret of barytes has an acrid and ſulphureous taſte, and is readily decompoſed by the atmoſphere, and ſulphat of barytes is precipitated along with ſulphur.

Hydro-ſulphuret of Strontian. This ſalt is formed preciſely in the ſame way as the former. The gas which it gives out when decompoſed by acids burns with a red flame like the other ſalts of ſtrontian.

Hydro-ſulphuret of Magneſia. If pure magneſia is diffuſed through water, and ſulphuretted hydrogen paſſed through, a ſolution is effected, and a hydro-ſulphuret of magneſia is formed.

Hydro-ſulphuret of Lime. This ſalt is obtained by paſſing ſulphuretted hydrogen through lime diffuſed in water. A ſtrong yellow ſolution is made which, when poured off clear from the remaining lime, ſhould be fully ſaturated with the gas, and the exceſs, if any, afterwards expelled by boiling. This ſolution has not been cryſtallized.

Berthollet, to whom we are indebted for the moſt accurate ideas and experiments on the hydro-ſulphurets, aſſigns to barytes the firſt rank in the order of affinities of the reſpective alkaline and earthy baſes to ſulphuretted hydrogen. As potaſh precipitates lime from the hydro-ſulphuret of lime, it precedes lime in affinity, and lime precipitates and decompoſes the hydro-ſulphurets of ammonia and magneſia. The order of affinity therefore is, probably, barytes, ſtrontian, potaſh, ſoda, lime, ammonia, and magneſia, the two latter nearly equally. When an alkaline hydro-ſulphuret is added to any earthy ſalt, (thoſe of alumine and zircon excepted) no precipitation takes place, either becauſe no decompoſition occurs, or becauſe the new compounds are equally ſoluble with the former. The ſolutions of alumine and zircon, however, are precipitated by the alkaline hydro-ſulphurets, as well as all the metallic ſalts.

The action of the alkaline hydro-ſulphurets on metallic ſalts will be afterwards mentioned.

Sulphurets or Hepars, *Liver of Sulphur. Sulfure* of Berthollet, and other French chemiſts.

When ſulphur is melted with an alkali a brown uniform maſs is produced, which as long as it continues dry is a ſimple combination of ſulphur and alkali. But while diſſolving in water a certain quantity of ſulphuretted hydrogen is immediately generated, which remains in the ſolution and unites with the ſulphur and alkali, but may be expelled by the addition of an acid, which at the ſame time precipitates the greater part of the ſulphur in a ſtate of purity. The liquid ſulphurets therefore contain ſulphur, alkali or alkaline earth, and ſulphuretted hydrogen, ſo that they differ from the hydro-ſulphurets of the ſame baſes in containing a large exceſs of ſulphur, and therefore give with acids a copious precipitate of ſulphur, which the ſimple hydro-ſulphurets do not.

Berthollet conſiders the ſulphuretted hydrogen in the liquid alkaline ſulphurets as the intermede by which the ſulphur is diſſolved in the alkali, and therefore as an eſſential part of the compound, and he denies the poſſibility of a liquid ſulphuret exiſting without containing ſulphuretted hydrogen in its compoſition. Hence he terms theſe compounds *Sulfures Hydrogenés*, which Mr. Chenevix calls *Hydroguretted Sulphurets*, and which may with equal propriety be termed *Sulphuretted Hydro-ſulphurets*.

But it is not every combination of ſulphur, ſulphuretted hydrogen, and a baſe, to which this term can, as we apprehend, be juſtly given, but only to that compound in which the whole of the ſulphur may be ſuppoſed to be united entirely with the ſulphuretted hydrogen, and through its intervention, to the baſe; or in other words, to a compound in which no further addition of ſulphuretted hydrogen will cauſe a precipitation of ſulphur. For the common liquid ſulphurets (made either by uniting ſulphur to an alkali by fuſion, and diſſolving the melted maſs, or by boiling the alkaline ſolution with ſulphur) contain a very large exceſs of ſulphur, moſt of which is ſeparated by every acid, and alſo a great part of it by ſulphuretted hydrogen, which here as in many other inſtances performs the part of an acid, and uniting to the alkali with a ſtronger affinity than ſulphur does, expells part of it, but alſo diſſolves another portion, and carries this latter along with it into the compound which it then forms. The proper ſulphuretted hydro-ſulphurets therefore are thoſe which are made by digeſting a hydro-ſulphuret with ſulphur, which, as Berthollet has ſhewn, takes up a portion of it, and again depoſits it on the addition of a ſtronger acid. Perhaps too the hydro-ſulphurets when they have been ſo long expoſed to the air as to turn yellow and depoſit ſulphur by the addition of an acid, may be conſidered as ſulphuretted hydro-ſulphurets, though in a much leſs concentrated ſtate than the former.

With regard to the common liquid ſulphurets, Prouſt has alſo ſhewn that the proportion of ſulphuretted hydrogen which they contain, varies ſo much, and is ſo little proportioned to the quantity of ſulphur actually preſent in the ſolution, as to render it extremely improbable that the whole, or even the greater part of the ſulphur is united to the alkali in ſolution by the intervention of the ſulphuretted hydrogen which they all confeſſedly contain.

The ſame excellent chemiſt has alſo given a method (which we ſhall preſently mention) by which every ſenſible portion of ſulphuretted hydrogen may be extracted from the ſolution; whilſt the alkaline baſe and the greater part of the ſulphur remain untouched,—another preſumptive proof that ſulphuretted hydrogen is not eſſential to the liquid ſolution of ſulphur in alkali.

We ſhall therefore retain the terms *dry* and *liquid ſulphuret*, to ſignify the common ſolid and fluid combinations of ſulphur with a baſe, and proceed to deſcribe the individual ſulphurets.

Sulphuret of Potaſh. Common Liver of Sulphur. The combination of ſulphur and potaſh is that which has been the longeſt known to chemiſts, and may be prepared in ſeveral ways. The antient method is the following: mix two parts of dry carbonat of potaſh with one of ſulphur and melt the mixture in a crucible with a heat gradually raiſed to redneſs, till the whole flows into an uniform maſs. As the potaſh is carbonated, a conſiderable efferveſcence ariſes when the materials begin to melt; ſo that the crucible ſhould be large and the heat gradual. When the ſwelling of the maſs has ſubſided and the whole remains in quiet fuſion, pour it out on a ſmooth greaſed ſtone, and as ſoon as it is cool enough to be handled, break it and put the exceſs in the ſolution, and is diſſolved in the pieces into a well cloſed dry bottle. The ſulphuret thus prepared is a hard, brittle, ſhining, heavy maſs, ſomewhat vitreous in its fracture, and of a deep brown or *liver* colour, whence the antient name of liver of ſulphur. As long as it remains dry it is without ſmell. On laying a minute portion on the tongue it taſtes exceſſively ſharp, burning and bitter, along with the peculiar nauſeous flavour of ſulphuretted hydrogen. When the ſolid ſulphuret is expoſed to the air it firſt turns green, which paſſes to grey, it alſo abſorbs moiſture pretty rapidly, and then begins to exhale the odour of ſulphuretted hydrogen, but it does not actually deliqueſce as melted potaſh alone does. When moiſt, it ſtains the ſkin of a yellowiſh brown which is difficult to remove.

This ſulphuret however is not entirely pure, for being made with a carbonated alkali it retains ſome carbonic acid, though much of it eſcapes during the fuſion, and hence on the affuſion of an acid, carbonic acid gas riſes in mixture with the ſulphuretted hydrogen. The pure dry ſulphuret muſt therefore be made with dry cauſtic potaſh, melted with about its own weight of ſulphur. The mixture in this caſe enters into fuſion, and the union is compleat before it reaches a red heat.

When cauſtic potaſh and ſulphur are rubbed together in a mortar they unite rapidly, the mixture grows hot, and ſoon is converted into a yellowiſh green maſs which exhales a fetid ſmell. In this caſe the moiſture which the alkali abſorbs from the air aſſiſts the combination.

A ſolid ſulphuret of potaſh may alſo be formed by mixing dry ſulphat of potaſh with about a ſixth of its weight of charcoal, and melting the mixture in a red heat for a conſiderable time. In this caſe the ſulphuric acid is decompoſed by the charcoal with much intumeſcence, and the ſulphur reſulting from the decompoſition unites with the alkali, and the whole forms a dark brown ſulphuret. This however is much leſs pure than the ſulphuret made by direct combination, for beſides any undecompoſed ſulphat which it may contain, it holds in ſolution a quantity of charcoal. Charcoal therefore is ſoluble in a red heat in this ſulphuret. When the dry ſolid ſulphuret is urged with a violent and long continued heat, the ſulphur is again driven out, along with part of the carbonic acid if a carbonated potaſh had been uſed, and alkali alone remains. If a dry fixed acid ſuch as the phoſphoric or boracic be mixed with the ſulphuret and heated, the ſulphur is expelled more eaſily, and the acid and potaſh remain behind. In all theſe proceſſes no ſulphuretted hydrogen is given out provided the ſulphuret and other ſubſtances be quite free from moiſture.

Liquid ſulphuret of potaſh is made either by diſſolving any of the dry ſulphurets in water, which is done with the utmoſt eaſe, or by diſſolving ſulphur directly in a ſolution of cauſtic potaſh with a boiling heat. It is then a yellow fetid liquor, exceſſively acrid and cauſtic if concentrated, changing vegetable colours like the alkalies; and alſo, like theſe, corroding animal and vegetable matter. It diſſolves many metals with rapidity, bringing them to the ſtate of a ſulphuret. When kept for a time even in cloſe veſſels it depoſits ſulphur.

The liquid ſulphuret is well known for the facility with which it abſtracts oxygen from common air or any mixture of oxygen, and hence its uſe in *Eudiometry*, as has been fully explained under that article.

When the liquid ſulphuret is made with perfectly cauſtic alkali, it gives out no ſulphuretted hydrogen by heat, at leaſt not in a heat of boiling water, but when made with carbonated alkali a conſiderable quantity of gas is given out which however is chiefly carbonic acid. This ſulphuret is alſo ſoluble with eaſe in alcohol.

When muriatic or any other acid is added to ſolid ſulphuret of potaſh, there is a copious diſengagement of ſulphuretted hydrogen) mixed with carbonic acid, if a carbonated alkali had been employed) and a large quantity of ſulphur is precipitated. The liquid ſulphuret alſo gives out with an acid a large quantity of the gas or gaſſes, and the mixture becomes immediately turbid and thick by the abundant precipitation of ſulphur. The latter when waſhed and dried is very pure ſulphur of a white or cream colour, and is called *Milk* or *Magiſtery of ſulphur*, or *Precipitated ſulphur*.

The action of mercury and its oxyds on the liquid ſulphurets and hydroſulphurets has been urged with great ingenuity by Prouſt,[*] in explanation of the nature of theſe compounds. Running mercury agitated with the pure colourleſs hydroſulphurets is not changed in any degree, ſo that this metal cannot take ſulphur from hydrogen when they are in perfect ſaturation and united with an alkaline or earthy baſe. But when the hydroſulphuret has begun to become yellow by ſhort expoſure to air, that is to ſay, when by an oxydation of part of the hydrogen the ſulphur which was united to it becomes in

[*] Journ. de Phyſ. tom. 59. p. 267.

xceſsin the [illegible] and is diſ-ſolved in

remaining ſulphuretted hydrogen, the mercury extracts from the ſolution this exceſs of ſulphur, (immediately, from the hydro-ſulphuret of ammonia, and in a ſhort time, from the other hydroſulphurets) and the liquid returns to the ſtate of ſimple hydro-ſulphuret. A portion of the ſulphuretted mercury remains diſſolved, whilſt the ſolution is concentrated, but on diluting with water or alcohol it becomes turbid, and black ſulphuret of mercury is precipitated, and the liquor is again reſtored to the ſtate of ſimple hydroſulphuret of the alkali employed. If however the exceſs of ſulphur is ſo great as to bring the mercury at once to the ſtate of red ſulphuret none of it is diſſolved, though the ſame change takes place in the liquor. Mercury therefore in *the metallic ſtate* analyzes all theſe compounds of ſulphur, ſulphuretted hydrogen and alkali, by extracting all the ſulphur except that portion which is ſaturated with hydrogen, and in the ſtate of ſulphuretted hydrogen; and hence it almoſt entirely extracts the ſulphur from thoſe liquid ſulphurets which ſcarcely effervesce with acids, and contain but a minute portion of ſulphuretted hydrogen, and reduces them almoſt to the ſtate of ſimple alkaline ſolutions.

But on the other hand a preciſely oppoſite effect takes place when the *red oxyd of mercury* is uſed, for when this is agitated with a hydroſulphuretted alkali, its firſt action is to decompoſe all the ſulphuretted hydrogen which it contains, which is attended with a ſenſible evolution of heat; and if no more oxyd be uſed than is neceſſary to engage the hydrogen, the remaining liquor becomes yellow, but remains clear after the ſubſidence of the oxyd, and is a ſimple liquid ſulphuret, from which muriatic acid precipitates ſulphur, but without the evolution of a particle of ſulphuretted hydrogen. If an additional quantity of red oxyd be added, the ſulphur is precipitated in combination with the metal, and the ſupernatant liquor is then little elſe than a ſolution of potaſh, holding a little oxyd of mercury, and ſometimes ſulphite of potaſh. A ſimilar change takes place with the common liquid ſulphuret of potaſh, which, as already mentioned, conſiſts of ſulphur, potaſh, and hydroſulphuret of potaſh. The firſt portion of oxyd engages the hydrogen of the hydroſulphuret, and detaches the ſulphur belonging to it, which diſſolves in the ſulphuret that remains in ſolution, and by deſtroying the hydrogen, takes from the ſolution of the property of effervеſcing with an acid. The oxyd alſo loſes oxygen, which unites with the hydrogen, and the metal abſorbs a portion of ſulphur and becomes black ſulphuret, part of which remains in ſolution. This firſt change takes place without any effervеſcence, and with diſengagement of ſenſible heat. But on adding a freſh portion of oxyd the heat is renewed, an effervеſcence occurs owing to the eſcape of part of the oxygen of the oxyd, the mercury becomes ſaturated with ſulphur and precipitates, and the remainder of the oxygen acidifies the ſulphur, and ſulphite of potaſh is found in ſolution.

The principal point eſtabliſhed by this excellent chemiſt in theſe experiments, is the poſſibility of ſubtracting all the ſulphuretted hydrogen from a liquid ſulphuret (at leaſt to that degree as to render it non-effervеſcent with an acid) whilſt the alkali and ſulphur alone remain in ſolution; and hence as the poſſibility of a ſimple liquid ſulphuretted alkali is eſtabliſhed, it may fairly be inferred that ſulphuretted hydrogen is not the principal intermede by which ſulphur and potaſh are held in liquid combination in the common ſolutions of the ſulphurets.

Sulphuret of Soda. This combination may be made either dry or liquid, by all the methods in which the ſulphuret of potaſh is produced, and it has the ſame general chemical properties which have been deſcribed as belonging to the ſulphuret of potaſh.

Sulphuret of Lime. Lime being infuſible *per ſe*, the combination between lime and ſulphur can ſcarcely, if at all, be made in the dry way; but a liquid ſulphuret of lime is readily formed by boiling together ſulphur, lime, and water. The proportions are of not much conſequence: the following anſwer very well: put into a glaſs mattraſs three ounces of well-burnt lime, one ounce of ſulphur, and about a quart of diſtilled water. The ſulphur ſhould firſt be rubbed with a little of the water, that it may mix uniformly, and the lime ſhould be broken down. Bring the liquor to a boiling heat, and continue it for half an hour or an hour, ſhaking it frequently during the time. The liquor ſoon becomes clear by ſubſidence as ſoon as removed from the fire, and a fine yellow ſtrong ſolution of ſulphuret of lime may be poured off clear from the ſettlings, which ſhould be kept in a well cloſed bottle.

Though ſulphur is abſolutely inſoluble in water, and lime very ſparingly ſoluble, the ſulphuret is conſiderably ſo, and when much concentrated when hot, part of it ſeparates by cooling into cryſtals not eaſily reſoluble in the liquid, which are probably ſimple hydro-ſulphuret of lime.

When liquid ſulphuret of lime is expoſed to the air, it abſorbs oxygen pretty rapidly (as all the liquid ſulphurets do), and the ſulphur changes to ſulphuric acid; ſo that the ſurface of the liquor is ſoon covered with a hard cruſt of ſulphat of lime, which prevents the fluid beneath from being acted on in the ſame manner, unleſs the cruſt is broken by ſhaking. This ſalt has been propoſed to be uſed inſtead of the alkalies in bleaching, as all the ſulphurets poſſeſs highly detergent qualities, and this can be prepared much cheaper than the alkaline ſulphurets. Mr. William Higgins, of Dublin, the inventor, gives the following proportions:[a]—boil in an iron kettle, for half an hour, 4lbs. of ſulphur, 20lbs. of lime, well ſlacked and ſifted, and 16 gallons of water, with frequent ſtirring. This yields, after a ſhort ſubſidence, a clear ſulphuret of the colour of ſmall beer, and the ſame quantity of freſh water may be poured on the reſidue to extract the remaining ſulphuret. For the purpoſe of bleaching, the whole quantity of liquid is to be made up to ſixty gallons, and in this brown linen cloth may be ſteeped for twelve or eighteen hours, alternating with oxymuriat of lime, for about ſix times, by which it will acquire the requiſite whiteneſs. The cold liquor anſwers nearly, if not entirely, as well as the hot.

Sulphuret of Barytes and Strontian. The liquid ſulphurets of theſe earths may be made either by boiling the pure earth with ſulphur and water, or by calcining the ſulphats of theſe earths with charcoal, to convert them into ſulphurets, and diſſolving the latter out from any remaining undecompoſed ſulphat. It has been already mentioned, under the head of *Hydroſulphuret*, that theſe ſolutions, when fully ſaturated, depoſit cryſtals which are pure hydroſulphurets, ſince they effervesce ſtrongly with an acid, and do not depoſit ſulphur in the proceſs. But the entire ſolution contains an exceſs of ſulphur, which will ſeparate on adding an acid.

Sulphuret of Ammonia. Though *ſulphuretted-hydrogen* and ammoniacal gas, will combine in the dry way into a hydro-ſulphuret of ammonia, *ſulphur* cannot be united with this alkali except in the liquid form, and this too is not readily effected, except through the medium of diſtillation; for when ſulphur and liquid ammonia are ſimply digeſted together, it requires a conſiderable time before any ſolution of the ſulphur is obtained.

The liquid ſulphuret of ammonia produced by diſtillation, appears to have been firſt noticed by Boyle, who obſerved its fuming property when expoſed to air, whence it was called *Boyle's Fuming Liquor*, or *Volatile Liver of Sulphur*. The proceſs as given by Beaumé, ſomewhat improved, is the following: mix together in a mortar, and put into a retort, 3lbs. of ſlacked lime, 1lb. of ſal-ammoniac, 8 oz. of flowers of ſulphur; and add to this, when in the retort, 6 oz. of water. Adapt a tubulated receiver, and proceed to diſtillation with a gentle heat. The firſt drops that condenſe are nearly watery, but thoſe that follow are yellow; and when about 6 oz. of liquor has diſtilled over, a vaſt quantity of white elaſtic vapour ariſes, which fills the receiver, and would burſt it, if it had not vent, and of which only a portion can be condenſed, and with great difficulty. The fire is then to be kept up ſteadily for an hour or more, till the bottom of the retort becomes ſlightly red, during which about ſix or eight ounces more of liquid are obtained.

The product of this diſtillation is a yellow, pungent liquid, ſmelling ſtrongly both of ammonia, and of ſulphuretted hydrogen, and giving out abundance of white fumes the moment it is uncorked. It is the liquid ſulphuret of ammonia. In this proceſs the ammonia, expelled from the ſal-ammoniac by means of the lime, acts upon the ſulphur in the moment of its formation, diſſolves the ſulphur, and, together with the water preſent, riſes in vapour, and condenſes in the receiver. Though only ſix ounces of water are added to the mixture, full double the quantity is obtained, the reſt being expelled from the ſlacked lime by the heat. If leſs water is added, the product is ſtill more fuming, and there is a ſtill greater waſte of incoercible vapour. This waſte, however, was only incurred before the invention of Woulfe's apparatus; for by its adoption the whole of the vapour may be condenſed, either in water, or in an alkaline ſolution, at pleaſure.

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To aſcertain the preciſe nature of this fuming ſulphuret, Berthollet made the following experiments: the materials for producing it, namely, lime, ſulphur, and ſal-ammoniac, were mixed in a retort, and the product condenſed as uſual; but was received in two ſeparate portions, the firſt of which was of a light yellow, and highly fuming; the ſecond was of a much deeper colour, and not fuming. Theſe were put into ſeparate veſſels, and into a third was poured ſome liquid hydro-ſulphuret of ammonia, made by ſaturating liquid ammonia with ſulphuretted hydrogen gas, and which did not fume. Muriatic acid was then added to each; and with the firſt, namely, that containing the fuming part of the diſtilled liquid ſulphuret, gave but little ſulphuretted hydrogen, and cauſed but little ſulphur to precipitate, though a conſiderable quantity of the acid was required to ſaturate it: with the ſecond, namely that containing the portion of the diſtilled liquid which gave no fumes, more efferveſcence was excited, more ſulphuretted hydrogen was evolved, and more ſulphur was precipitated: with the third, namely that containing the ſimple hydro-ſulphuret of ammonia, much of the gas was given out, but little or no ſulphur was depoſited. Other portions of the ſecond and third ſolutions were taken, and liquid ammonia was added to each, which immediately gave them both the fuming property, and rendered the ſecond liquor in every reſpect ſimilar to the firſt.

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[a] Phil. Journal, Vol. 3.

It therefore appears that the property of ſending forth white fumes may exiſt both in the liquid ſulphuret and in the ſimple hydro-ſulphuret, and is produced by an exceſs of ammonia, which not finding ſufficient ſulphur or ſulphuretted hydrogen to keep it down, is volatilized in the air, and carries with it part of the ſulphuretted hydrogen contained in the ſolution. Hence too, when the fuming hydro-ſulphuret is digeſted with ſulphur, it diſſolves a portion, and then loſes its fuming property, as the exceſs of ammonia is then engaged by the ſulphur. This latter compound (that is, hydro-ſulphuret of ammonia, digeſted with ſulphur to ſaturation) has a deep colour and an oily conſiſtence, and does not depoſit ſulphur by any further addition of ſulphuretted hydrogen; and therefore it is ſtrictly a *ſulphuretted hydro-ſulphuret*, or *hydroguretted ſulphuret*, in the ſenſe to which we have limited it in the beginning of this article; and an exceſs of ammonia would convert it into a compound exactly the ſame as the fuming ſulphuret deſcribed by Boyle. The latter ſoon loſes it's fuming property on expoſure to air, after which it abſorbs oxygen like the other ſulphurets, and a white ſulphur is depoſited.

SUPER-SULPHURETTED SULPHUR. *Hydroguretted Sulphur of* Chenevix, *Soufre Hydrogené.* This is a very curious combination, diſcovered by Berthollet, and conſiſts ſimply of ſulphuretted hydrogen, with a large exceſs of ſulphur, and without any alkaline or other baſe. It is prepared by mixing at once a large proportion of muriatic acid with liquid ſulphuret of potaſh, or better, by pouring the ſulphuret in ſmall portions into the acid, during which moſt of the ſulphur is precipitated as uſual, but very little efferveſcence takes place, and the ſulphuretted hydrogen, inſtead of eſcaping in a gaſſeous form, unites with a portion of the ſulphur, and condenſes with it into a liquid of the appearance of oil, which gradually collects at the bottom of the veſſel in which the mixture is made. This ſubſtance was firſt noticed by Scheele.

When this ſuper-ſulphuretted hydrogen is mixed with liquid ſulphuret of potaſh, ſulphur is depoſited; for, as has been already mentioned, the liquid ſulphuret is capable of combining with, and actually abſorbs from the new compound, an additional portion of ſulphuretted hydrogen, which in conſequence abandons its exceſs of ſulphur. Another portion of the precipitated ſulphur is alſo furniſhed by the liquid ſulphuret during its further ſaturation with ſulphuretted hydrogen, which in this reſpect acts as an acid, as has been before noticed. As therefore the portion of ſulphur which is already united with an alkali is able to abſtract ſulphuretted hydrogen from its combination with ſulphur alone, it is obvious that the ſuper-ſulphuretted hydrogen cannot be produced till there is a ſufficient exceſs of acid to engage all the alkali, and detach it from the ſulphur, which happens when a little of the liquid ſulphuret is poured into a larger quantity of acid. The ſuddenneſs of the decompoſition, and denſity of the fluid produced by the copious depoſition of ſulphur, appear alſo to aſſiſt in forming this ſingular compound.

Super-ſulphuretted hydrogen may be conſidered as a compound in which the elaſticity of the gas is kept down rather than entirely ſubdued, by the ſolid with which it is condenſed into chemical union, ſo that this union is very ſlight, and is readily broken in circumſtances at all favourable to the gas reſuming its elaſticity. Hence when it is kept in a phial with water, on the ſurface of which it ſwims, it is conſtantly in a ſtate of ebullition, and if the phial is uncorked, the whole of the ſulphuretted hydrogen exhales, and the ſulphur returns to its original ſtate, and falls to the bottom of the water.[c] Alſo if a little of this liquid be taken in the mouth, it gives a pungent, bitter, hydro-ſulphureous taſte which ſoon goes off, leaving nothing in the mouth but ſolid ſulphur, ſticking to the teeth.

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[c] Prouſt.

When a ſolution of potaſh is added to ſuper-ſulphuretted hydrogen, a ſmall portion of ſulphuretted hydrogen exhales, and the remainder unites with the potaſh forming a ſolution which reſembles in every reſpect the common liquid ſulphuret of potaſh.

As the foregoing ſubject is ſomewhat intricate, it may be uſeful to recapitulate ſhortly, the various combinations of ſulphur, hydrogen, and an alkaline or earthy baſis, with their diſtinguiſhing characters.

1. *Sulphuretted Hydrogen,* a gas ſomewhat heavier than common air, compoſed of hydrogen holding ſulphur in ſolution; has a peculiar fetid ſmell, is inflammable, is abſorbed by water, does not render lime-water immediately turbid, when in liquid ſolution is readily decompoſed by expoſure to air, or by the acids which eaſily part with their oxygen, ſuch as the nitrous and oxymuriatic, during which its hydrogen is firſt engaged and quits the ſulphur, which therefore is precipitated in its natural form. Sulphuretted hydrogen reddens litmus, unites largely with alkaline and earthy baſes, forming with moſt of them cryſtallizable ſalts in which the baſe is nearly if not entirely neutralized, ſeparates ſulphur from its combination with alkalies, and in all theſe reſpects performs the function of an acid. It is however detached from its combinations by every acid, and then re-aſſumes its gaſſeous form, and paſſes off by efferveſcence. It blackens the ſolutions of many metals, and precipitates moſt of them, but not the ſalts of iron and manganeſe.

2. *Hydro-ſulphurets* are the ſaline combinations of ſulphuretted hydrogen, with the ſeveral alkaline or earthy baſes. They are, when recently made, perfectly clear and colourleſs, and on the affuſion of a ſtrong acid they efferveſce, and give out abundance of ſulphuretted hydrogen, but no ſulphur is precipitated, the hydrogen being ſufficient to carry off the whole of it. The ſulphur therefore is ſolely that which belongs to the conſtitution of ſulphuretted hydrogen. The hydro-ſulphurets by expoſure to air, abſorb its oxygen, and in ſo doing loſe a proportionate quantity of their hydrogen, whereby they turn yellow and cloudy, and on the affuſion of an acid they then both efferveſce, and depoſit ſulphur, ſo that in this ſtate the ſulphur is in exceſs relatively to the quantity of ſulphuretted hydrogen.

3. *Sulphuretted Hydro-ſulphurets* are hydro-ſulphurets holding an exceſs of ſulphur in ſolution, and are made either by digeſting the pure hydro-ſulphurets with ſulphur, or by expoſing them to the atmoſphere for a ſhort time, till they turn yellow, and till a portion of the hydrogen is deſtroyed. The former method however gives the moſt concentrated ſolution. Theſe compounds on the affuſion of muriatic acid both efferveſce and depoſit ſulphur, but on paſſing a freſh portion of ſulphuretted hydrogen through them, no ſulphur is ſeparated, and in this laſt circumſtance they differ from the common liquid ſulphurets.

4. *Super-ſulphuretted Hydrogen* is that ſingular liquid produced by decompoſing a liquid ſulphuret by a large quantity of acid, and conſiſts of ſulphuretted hydrogen exceſſively loaded with ſulphur, and adhering to it ſo looſely as totally to quit it on applying a gentle heat, or expoſure to air. An alkaline baſe therefore is a neceſſary intermede to effect a permanent union between ſulphur and ſulphuretted hydrogen, and hence the addition of an alkali to this ſuper-ſulphuretted hydrogen, brings it to the ſtate of ſulphuretted hydro-ſulphuret.

5. *Dry Sulphurets* or *Hepars.* Theſe are ſimple combinations of ſulphur and alkali effected by fuſion at a low red heat. When the alkali is carbonated a part of the carbonic acid remains in union, and is expelled by an acid. The dry ſulphurets of the alkaline earths can only be made by decompoſing their ſulphats by fuſion with charcoal, and then are impure.

6. *Liquid Sulphurets.* The ſolution of any dry ſulphuret in a watery liquid, or of ſulphur in a liquid alkali or alkaline earth, generates a quantity of ſulphuretted hydrogen (though in no degree proportionate to the ſulphur diſſolved) which mixes with the other conſtituents and the whole forms a cauſtic yellow liquid with ſtrong alkaline properties. It is compoſed therefore of the ſame materials as the ſulphuretted hydro-ſulphurets, that is to ſay, of ſulphuretted hydrogen, ſulphur, and an alkaline baſe, but differs from theſe ſalts in containing a much larger exceſs of ſulphur, and a much ſmaller quantity of ſulphuretted hydrogen, and hence the affuſion of an acid cauſes in general only a ſmall efferveſcence (ſometimes hardly perceptible) but a copious ſeparation of ſulphur; and beſides (which is a diſtinguiſhing mark) much ſulphur is precipitated by paſſing through it a current of ſulphuretted hydrogen.

In the liquid ſulphurets therefore the ſulphur ſeems to be held in ſolution by the alkali alone, and the ſulphuretted hydrogen to be but an acceſſary ingredient; whereas in the ſulphuretted hydro-ſulphurets the ſulphuretted hydrogen appears the principal ſolvent of the ſulphur, and the alkali to act as it were, as an intermede to render this union more permanent.

7. *Simple Liquid Sulphurets.* On the authority of Prouſt whoſe experiments have been already detailed, we may admit the exiſtence of a ſimple liquid ſolution of ſulphur in alkali when the ſulphuretted hydrogen has been withdrawn by adding red oxyd of mercury. This liquid depoſits ſulphur copiouſly on adding acids, but does not efferveſce, and gives out no ſulphuretted hydrogen.

8. *Fuming Ammoniacal Hydro-ſulphurets and Liquid Sulphurets.* The liquid combinations of ſulphur or ſulphuretted hydrogen, or both together, with ammonia, have the property of emitting white fumes when the alkali is in exceſs, which therefore muſt be conſidered as another ſpecies of this claſs of ſubſtances.

Sulphur unites directly with all the metals except gold and zinc. Chemiſts have diſtinguiſhed the different combinations of ſulphur with the metal, ſulphur with the metallic oxyd, and ſulphuretted hydrogen with the metallic oxyd, with or without an exceſs of ſulphur. Of theſe combinations the ſimple ſulphuret, or union of ſulphur with the reguline metal is by far the moſt intimate, and it is even doubtful if there can be a proper ſulphuretted oxyd in the dry ſtate. For if ſulphur is mixed with a metallic oxyd and heated in a cloſe veſſel to the perfect fuſion of the mixture, a quantity of ſulphurous acid is always firſt given out, owing to a deoxydation of the oxyd by a portion of the ſulphur, and the metal (nearly if not entirely in a reguline ſtate) remains in permanent union with the remainder of the ſulphur. This important fact has been clearly illuſtrated by the experiments of Prouſt[1] on the oxyds and ſulphurets of antimony. If 100 parts of antimony be diſtilled with as much ſulphur, all the exceſs of the latter flies off, and there remains at laſt 135 parts of ſulphuret, which continues permanent at a heat more than ſufficient to volatilize ſulphur alone. If on the other hand a quantity of oxyd of antimony equivalent to 100 parts of the metal, be diſtilled with as much ſulphur, a large quantity of ſulphurous acid flies off along with the exceſs of ſulphur, and the reſidue is as before 135 parts of ſulphuret. The other metallic oxyds appear to act in a ſimilar way, whence we may infer it as a general rule that in all the dry combinations of a metal and ſulphur, after the utmoſt effect of expoſure to a heat capable of ſubliming ſulphur has been given, the metal is nearly if not entirely reguline, provided there has been ſulphur enough added to engage all the oxygen which the metal may have contained.

When metallic ſolutions are decompoſed by the liquid alkaline ſulphurets, the metal combines with the ſulphur, and a part, at leaſt, of the ſulphuretted hydrogen is deſtroyed, its hydrogen uniting with the oxyd of the ſolution to bring it to the metallic ſtate, and its ſulphur mixing with the other ſulphur of the ſulphuret. Hence moſt of the precipitates formed in ſuch caſes are ſimple ſulphurets, and not hydro-ſulphuretted oxyds. It is even doubtful if there can be a hydro-ſulphuretted oxyd, for the firſt action of ſulphuretted hydrogen is to reduce the oxyd to the metallic ſtate, unleſs inſtead of a compleat reduction, it brings it to the ſtate of loweſt oxygenation. The production of ſulphuretted hydrogen by the affuſion of an acid on the precipitate formed in ſuch caſes is not a ſatisfactory proof of its being a hydroſulphuret, as it is with the alkaline and earthy hydro-ſulphurets, for with the metallic compounds, the ſulphuretted hydrogen may be *generated* by the action of the acid, inſtead of being merely *evolved*. This is obvious from the uſual way of producing this gas by muriatic acid and ſulphuret of iron, which therefore throws much difficulty in the way of the analyſis of theſe metallic compounds. It alſo appears from this that there cannot be a ſimple metallic hydroſulphuret, but that this compound whenever it is formed muſt always exiſt with exceſs of ſulphur, for there is no other method of producing a hydro-ſulphuret than by adding liquid ſulphuretted hydrogen, or an alkaline or earthy hydroſulphuret to a metallic ſolution, and as already mentioned a part of the ſulphuretted hydrogen muſt be decompoſed, and an exceſs of ſulphur produced before any combination can take place. The whole of this ſubject however is ſtill involved in many difficulties, and requires further experiments.

SULPHURIC ACID, Vitriolic acid, Oil of Vitriol. *Acide ſulfurique*, Fr. *Schwefelſaure*, Germ.

This acid, perhaps the moſt important of any for its extenſive uſe, is ſaid to have been found by Baldaſſari in a concrete ſtate, lining a grotto in Mount St. Amiato in Tuſcany; it alſo occurs in the crevices of volcanic mountains, and diſſolved in a few mineral waters. It is not however from any of theſe ſources that the ſulphuric acid of commerce is obtained, the whole of this being procured either from the diſtillation of ſulphat of iron, or from the combuſtion of ſulphur.

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[1] Journ. de Phyſ. tom. 55.

Sulphat of iron (or green vitriol) as we have elſewhere ſhown, conſiſts of ſulphuric acid, water, and oxyd of iron; by proper methods the acid may be ſeparated from the other ingredients of the ſalt; and this continued to be the only origin of ſulphuric acid in the great way, till the diſcovery, by the manufacturing Engliſh chemiſts, of the art of preparing it by the combuſtion of ſulphur. As this latter diſcovery has not however as yet entirely ſuperſeded the former, we ſhall give an account of both, beginning with the moſt ancient.

Sulphuric acid is thus prepared at Bleyl, in Bohemia.[a] A long horizontal furnace or gallery of brick-work is conſtructed capable of receiving a number of retorts; the retorts themſelves are pear-ſhaped veſſels, with a ſlightly curved neck, by which they fit into earthen receivers nearly of the form of common retorts. The whole apparatus being prepared, each retort is charged with 3 lbs. of ſulphat of iron, previouſly calcined at a full red heat, and the fire is lighted. The firſt effect of the heat is to drive off the moiſture abſorbed by the vitriol in the interval between its calcination and diſtillation; this phlegm being only very ſlightly acidulous is allowed to eſcape, and when it ceaſes to come over, the receiver with a little water in it is luted on to the retort; the fire is now raiſed and kept up briſk for 32 hours, during which time the acid riſes in the form of denſe white vapours, which fill the receiver, and are there abſorbed by the water. Theſe vapours being at a high temperature ſoon render the receiver very hot, hence the workmen judge of the termination of the proceſs by the receiver becoming cool in conſequence of the vapour ceaſing to riſe. The red oxyd of iron or colcothar, is now taken out of the retort and its place is ſupplied with a freſh charge of calcined vitriol; the diſtillation then takes place as already deſcribed, except that the former produce of acid is not emptied out of the receiver, and therefore there is no occaſion to add any water. If the retort is well made and carefully luted all over, it will laſt for three ſucceſſive diſtillations, and the quantity of acid obtained is nearly equal to half the weight of the calcined ſulphat.

If the acid be examined at different periods of the diſtillation, it will be found to be more and more denſe according to the violence of the fire required for its extrication; the latter portion if received in a ſeparate veſſel will generally congeal upon cooling, hence it is called *glacial ſulphuric acid;* this property however is not entirely owing to its denſity, as we ſhall preſently ſhow.

The ſulphats of copper and zinc have occaſionally been employed, inſtead of the ſulphat of iron, but with a manifeſt diſadvantage, both becauſe they are dearer than the latter ſalt, and becauſe they require a higher and longer continued heat to drive off the whole of the acid.

The following is the uſual method of manufacturing ſulphuric acid from the combuſtion of ſulphur. A chamber is conſtructed of frame work, and lined with ſtrong ſheet lead; the only aperture is a ſmall door, made to ſhut very cloſe, the bottom of which is a little higher than the floor of the chamber. Water is poured into this chamber till it riſes to the heighth of an inch or two upon the floor, and a ſtand is introduced on which is placed an earthen pot containing a few pounds of ſulphur and nitre, in the proportion of from eight to ten of the former to one of the latter; this mixture is ſet fire to by means of a red hot iron, and the door is immediately cloſed; at the expiration of about ſix hours a ſecond charge of ſulphur and nitre is introduced, which after a ſimilar interval is replaced by a third, and ſo on without intermiſſion for a fortnight or three weeks. At the end of this period the water in the chamber is ſufficiently acidulated; it is accordingly transferred to a leaden boiler, where the greater part of the water is evaporated; in proportion however as the acid becomes more concentrated, it is more diſpoſed to corrode and diſſolve the lead of the boiler; therefore before this degree of concentration takes place, the liquor is transferred into large green glaſs retorts, where a degree of heat is applied ſufficient to drive off almoſt the whole of the water. As the acid becomes ſtronger it alſo becomes clearer and leſs coloured in conſequence of a portion of acid re-acting on the impurities with which it is tinged, and thus deſtroying them. When the acid is thus brought to the required denſity and clearneſs, it is poured out of the retorts into large globular glaſs bottles, ſurrounded with wicker work ſtuffed with ſtraw (called *carboys*) and is then brought into the market, under the name of *Oil of Vitriol*.

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[a] Fragoſo de Sequeira in Journ. de Phyſ. vol. LI. p. 40.

The ſulphuric acid obtained from the diſtillation of green vitriol exiſts ready formed in the ſalt, its extrication is a perfectly ſimple proceſs, and the only impurities that it can poſſibly contain are ſulphurous acid, and a very minute portion of oxyd of iron, and of the earth of the retort. When loaded with ſulphurous acid it has a ſuffocating odour, and when expoſed to the air gives out a white vapour like ſtrong muriatic acid; it uſed formerly to be ſold in this ſtate by the name of *fuming oil of vitriol*, and was further diſtinguiſhed by its property of congealing into a ſoft ice, at a very moderate degree of cold. By dilution with a little water, and ſubſequent boiling for a few minutes in a glaſs veſſel, the ſulphurous acid is driven off, and the reſidual fluid is common ſulphuric acid in a ſtate of very conſiderable purity.

It might be imagined *a priori*, that ſulphur would be convertible by ſimple combuſtion into ſulphuric acid, this however is by no means the caſe. In the firſt rude attempts to obtain ſulphuric acid by this proceſs, the method employed was the following: a large ſhallow baſon was half-filled with hot water, and an earthen crucible, or other convenient veſſel filled with melted and ignited ſulphur, was fixed by means of a ſtand in the middle of the baſon, and juſt above the ſurface of the water; a large bell glaſs was then whelmed over the pot of ſulphur, and brought nearly though not quite in contact with the water; in this ſituation the vapour ariſing from the combuſtion of the ſulphur, roſe into the bell glaſs where it mixed with the ſteam of the hot water, and condenſing trickled in drops down the ſides of the glaſs into the baſon. But though by this proceſs a certain quantity of ſulphuric acid was obtained, yet ſo large a portion of the ſulphur eſcaped in incondenſible ſuffocating ſulphurous acid gas as to render it both a very offenſive and uneconomical mode of proceeding. Nor does the want of ſucceſs in theſe experiments appear to have ariſen from any imperfection of the apparatus or want of care in the manipulation, for they have ſince been repeated by various manufacturers on a great ſcale, but with the ſame reſult as at firſt. Chaptal appears to have beſtowed particular care on this ſubject, we ſhall therefore ſtate the reſults of his experiments.[b] The apparatus employed by this able chemiſt was a leaden chamber with a ſtove conſtructed on the outſide, and communicating by means of a flue with the chamber. In this ſtove the ſulphur was melted, and a blaſt of air being directed on its ſurface, combuſtion took place, and the products of this combination paſſed into the leaden chamber, and were thus brought in contact with the water which it contained. When the current of air paſſed very rapidly over the ſulphur, only a very ſmall quantity of this latter ſuffered combuſtion, the greater part being ſimply involved in the air in a minutely divided ſtate, and depoſited within the chamber in the form of flowers of ſulphur. By moderating the rapidity of the current of air, the combination of the ſulphur with oxygen is more complete, a large quantity of ſulphurous acid is produced, and part of the ſulphur is found covering the ſurface of the water in form of a thin elaſtic ſkin. If the current of air is rendered ſtill ſlower, ſo as but juſt to keep up the combuſtion, the whole of the ſulphur is acidified, but ſo large a portion of it is in the ſtate of incondenſible gas, that the product of true ſulphuric acid is altogether inſignificant. In one of M. Chaptal's experiments he burnt in the courſe of ſeven days 1135 lbs. of ſulphur, at the end of which time ſo prodigious a quantity of ſuffocating gas poured out from the chamber as to render it neceſſary to ſtop the proceſs; in three or four days after, the door of the chamber was opened, and after the gas had eſcaped, it was found that the water on the floor of the chamber was covered with a flexible ſkin of ſulphur, and was ſcarcely at all acidulous to the taſte.

In a ſecond experiment the combuſtion was much ſlower, 2900 lbs. being burnt in the ſpace of thirty-three days; during the proceſs much ſulphurous acid gas eſcaped, and on the chamber being opened there was no appearance of ſublimed ſulphur or of film upon the water, ſo that the whole of the ſulphur had undergone combuſtion, but the product of condenſible acid was ſo ſmall that the water was only ſlightly acidulous, and ſcarcely effervеſced with carbonated alkali. Hence it appears, that though atmoſpheric air will effect the combuſtion of ſulphur, yet the product is little elſe than incondenſible ſulphurous acid.

Several other methods have been tried to ſupercede the neceſſity of employing nitre, but with little or no ſucceſs. Water contains a large proportion of oxygen in its compoſition, and is readily decompoſeable at a moderate heat by a variety of ſubſtances, attempts have been accordingly made to employ it for the oxygenation of ſulphur. If to ſome of this latter when melted and ignited, there be added water drop by drop, at ſhort intervals, the flame of the ſulphur will be enlarged, its colour will become of a yellowiſh tinge, and a denſe white vapour will ariſe from it, but this latter when condenſed appears to be only very ſlightly acidulated water highly charged with minutely divided ſulphur.[c] A more likely method of producing ſulphuric acid was by mixing with the ſulphur a portion of black oxyd of mangeneſe, capable of furniſhing a quantity of oxygen equal to that contained in the proportion of nitre uſually employed, but though this mixture has been treated in various ways, it does not appear capable of furniſhing a greater quantity of ſulphuric acid than when ſulphur is ſimply burnt in atmoſpheric air. Even oxygen gas itſelf when diſtributed by means of a pipe over the ſurface of heated ſulphur is by no means comparable in in efficacy to nitre; the rapidity of the combuſtion is indeed very rapidly increaſed, but the product is almoſt entirely ſulphurous acid gas.

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[b] An. de Chim. ii. p. 86.

When the method of producing ſulphuric acid by the combuſtion of ſulphur and nitre was firſt diſcovered, the apparatus employed was a ſeries of very large glaſs balloons, at the bottom of each of which was a little water to condenſe the vapour; only a ſmall quantity of the mixture could be burnt at once, and conſtant ſuperintendence was neceſſary to ſupply the balloons with freſh charges of the materials. In order to ſave much of this manual labour and the heavy loſs ariſing from the frequent fracture of the veſſels, leaden chambers were made uſe of, which beſides requiring leſs attendance, and being upon the whole cheaper, rendered it eaſier for the manufacturer to extend his eſtabliſhment to any required magnitude. Theſe chambers are of various conſtruction; the moſt ſimple and in moſt general uſe, are furniſhed only with two apertures, namely, a ſmall door, by which the water and the ſulphur and nitre are introduced, and a leaden pipe with a ſtop-cock, by which the water when acidulated is drawn off; other chambers have beſides a few ſmall apertures for the introduction of atmoſpheric air during the combuſtion, and a ſteam pipe connected with a boiler, it being found that if the water is introduced in the ſtate of ſteam, a much more rapid condenſation of the acid enſues than in the uſual way of proceeding. In ſome of the beſt contrived chambers the combuſtion of the nitre and ſulphur is effected in a ſeparate ſtove, and the acid vapour thus produced is poured by means of a pipe into the condenſing chamber.

There is a good deal of difference among the manufacturers as to the proportion of nitre employed, by ſome it is made equal to $\frac{1}{5}$ of the ſulphur, while by others it is not allowed to exceed $\frac{1}{10}$. This however appears to be ſatisfactorily eſtabliſhed, that within the above limits the greater the proportion is of nitre, the more eaſily condenſible will the acid vapour be, and the leſs ſulphur will be loſt in the form of ſulphurous acid gas. If the nitre exceeds $\frac{1}{5}$ of the ſulphur, the combuſtion will be ſo rapid as to drive into the chamber a conſiderable proportion of ſulphur unaltered. The acid vapour is of a denſe opake white colour, and according to Chaptal is conſiderably luminous: when as much of it is condenſed as is capable of being ſo in the uſual proceſs, the reſidue becomes quite tranſparent, and is for the moſt part a mixture of ſulphurous acid gas and nitrous gas; it has a peculiar and very pungent ſuffocating odour, and upon opening the door of the chamber, it preſently acquires a faint orange red colour, by combining with the oxygen of the air, and thus forming nitrous acid vapour; this as ſoon as formed re-acts on the leaden lining of the chamber, corroding it deeply, and is the principal cauſe of the ſulphat of lead, which common ſulphuric acid always contains, and often in conſiderable abundance. It would conduce much to the purity of ſulphuric acid, and might probably be found even to be an economical plan, to line the chamber with glaſs inſtead of ſheet lead; the general appearance of the chamber would then reſemble a green-houſe, and all the wood work ſhould be faced internally with glaſs; a compoſition of wax, maſtich, and fine ſand, would form a ſtrong cement for the glaſs, and little liable to be acted on by acid vapours, more eſpecially if the interſtices filled up with it were duſted with powdered glaſs or very fine ſand, while the cement was yet warm and adheſive. Such a chamber would have the additional advantage of allowing the operator to ſee what was paſſing within, without the neceſſity of opening the door.

With regard to the ſtrength of the acid when withdrawn from the condenſing chamber, we are informed by Chaptal, that in his manufactory it uſed to mark between 40° and 50° on Beaumé's areometer; it was then evaporated in leaden boilers, till it arrived at 60° of Beaumé, and was laſtly condenſed in glaſs retorts till it was equal to 66°, and was then at the common denſity of the oil of vitriol of commerce. We are told by the ſame author, that one part of ſulphur affords nearly two parts of ſulphuric acid at the above denſity: this however appears to be a miſtake. We ſhould imagine that in the common manufactories the loſs by ſulphurous acid gas would nearly counterbalance the increaſe from the addition of oxygen and water; indeed it is expreſsly ſtated by ſome authors that 100lbs. of ſulphur produce by combuſtion an equal weight of ſulphuric acid.

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[c] Chaptal, Application de Chimie aux Arts, &c. Vol. II.

It has been already mentioned that the common Engliſh ſulphur (and probably all that which is obtained during the roaſting of copper ore) is unfit for the preparation of ſulphuric acid, on account of a yellowiſh-brown colour that it gives to this fluid, and which it is extremely difficult to get rid of. For this reaſon the refined Sicilian ſulphur is the only kind that is employed in this manufacture, at leaſt in Britain. But though by the due ſelection of ſulphur one ſource of impurity is avoided, yet there are others which, according to the uſual mode of preparing this acid, it is impoſſible to eſcape. The watery acid as it runs from the leaden chamber, is neceſſarily mixed with ſulphat of lead, with a ſmall quantity of nitrous acid, and holds ſuſpended in a minutely divided ſtate a portion of ſulphur, from which it acquires a yellowiſh colour: during the evaporation in the leaden boilers, probably a little more ſulphat of lead is taken up. The high heat required for the final concentration of the acid in the glaſs retorts, by cauſing the nitrous and part of the ſulphuric acid to re-act on the diffuſed ſulphur and other inflammable impurities, takes away, for the moſt part, the colour from the fluid, and drives off the whole of the nitrous gas and ſulphurous acid, together with a portion of water: thus the only impurity that finally remains in the ſulphuric acid is ſulphat of lead. But it not unfrequently happens that the acid during concentration loſes its colour very ſlowly, to expedite which it is uſual to add a little nitre, the acid of which being ſet at liberty acts rapidly on the colouring matter and deſtroys it, being itſelf finally driven off in the ſtate of nitrous gas. The alkaline baſe of the nitre however remains diſſolved and combined with the ſulphuric acid, ſo that beſides ſulphat of lead it is further contaminated by ſulphat of potaſh, and if the nitre is added ſomewhat in exceſs, and only a little while before the concentration is finiſhed, it is very probable that a portion of nitrous acid will ſtill remain. Nor is it of trifling moment that the whole of the nitrous acid ſhould be expelled, for if the dyer or callico printer employs an impure acid of this deſcription in making Saxon blue (ſulphat of indigo) he will find to his coſt that he has got a green inſtead of a blue pigment. From the occaſional occurrence of the above and other ſimilar diſappointments it is that the dyers on the continent, when they can procure either the ſulphuric or the genuine *vitriolic* acid, always prefer the latter, notwithſtanding the great ſuperiority of its price.

Common ſulphuric acid may be freed from the ſulphats of lead and potaſh which it generally contains, by diſtillation; this, however, though apparently a very ſimple proceſs, is rather a nice matter to manage, according to the uſual method. Sulphuric acid is not capable of being diſtilled at leſs than a red heat, when therefore the denſe hot vapour firſt comes in contact with the necks of the retort and receiver, it is apt to break them, unleſs the precaution has been taken of thoroughly heating them by means of a pan of charcoal placed beneath, a minute or two before the diſtillation commences. All this riſk however may be avoided (and in ſome laboratories it actually is ſo) by connecting the glaſs body, in which the acid is boiled, with the receiver, by means of a tube of platina: boiling ſulphuric acid has not the leaſt action on this metal, and the vapour in its paſſage through becomes ſo far cooled and condenſed, that it flows into the receiver in drops.

Sulphuric Acid, when pure, is perfectly tranſparent and colourleſs; but the common oil of vitriol of the ſhops has almoſt always a very pale hair brown tinge, probably ariſing from the carbonization of a little of the cement with which the bottles in which it is kept are cloſed. In its general appearance and conſiſtence when ſhaken it is not unlike oil, whence it derived its commercial name *oil* of vitriol. It is entirely inodorous: to the touch it is at firſt ſmooth and unctuous, but it preſently after excites a violently burning ſenſation, and corrodes the ſkin with great rapidity; even when largely diluted with water, it is acerb and intenſely ſour, and ſets the teeth on edge. It changes moſt vegetable blues to red, and exhibits the other generic characters of acids in an eminent degree. Concerning the utmoſt poſſible denſity of this acid in an uncombined ſtate, there is a remarkable difference among chemical writers, according to Beaumé and Bergman it ſometimes amounts to 2.125. According to Wiegel, the ſpecific gravity of the fuming glacial ſulphuric acid is = 1.898, while that of the Engliſh ſulphuric acid cannot be brought higher than 1.851. Mr. Perceval[b] found that common ſulphuric acid of the ſpecific gravity of 1.842, after being heated to redneſs for half an hour in a retort, during which time it emitted copious white fumes of ſulphuric acid and ſulphurous acid gas, was increaſed to 1.852: but this concentrated acid was impure, ſince by dilution with water it depoſited a white powder, probably ſulphat of lead; being then diſtilled, the acid that came over appeared to be perfectly pure, and when concentrated by being heated for ſome time in a retort, its ſp. gr. was found to amount to 1.846. Hence it appears that there is a real difference in the extreme denſities of ſulphuric acid made from ſulphur, and that procured from the diſtillation of martial vitriol. Nor is this at all ſurpriſing if we attend to the circumſtances of their production. The ſulphuric acid when combined with oxyd of iron, with which it has a ſtrong affinity, and which is itſelf fixed in the fire, will neceſſarily be capable of being dephlegmated to a much higher degree than when the acid is expoſed to the action of heat in an uncombined ſtate as is the caſe in the concentration of the Engliſh ſulphuric acid.

The fixity of ſulphuric acid is very conſiderable: when in the ſtate of common oil of vitriol it requires nearly a red heat for its vaporization, and though when diluted with water it will boil at a conſiderable lower temperature, yet little elſe than water is driven off, and the acid becoming more and more concentrated, requires a continually increaſing heat to keep up its ebullition till it arrives at the degree neceſſary for the volatilization of the acid itſelf.

Sulphuric acid freezes, or cryſtallizes, by expoſure to cold, and it appears to congeal with more eaſe when moderately concentrated than when it is dilated: this remarkable circumſtance was firſt pointed out by the Duc d'Ayen, was then confirmed by Morveau, and has ſince been treated at large and in a very ſatisfactory manner by Mr. Keir.[d] This accurate obſerver found that ſulphuric acid of the ſp. gr. of 1.78, congeals at about 40° Fahr. but that if the denſity is either increaſed or diminiſhed, a greater cold is required for its congelation. Proceeding from the above denſity in each direction, he found that ſulphuric acid at the ſp. grs. of 1.786 and 1.775, or at any intermediate denſity, freezes when expoſed to the cold of melting ſnow; that if the energy of the freezing mixture be increaſed by the addition of common ſalt, it will congeal ſulphuric acid at the ſp. grs. of 1.841 and 1.75, or at any intermediate denſity; but that acid at the ſp. grs. of 1.815 on the one hand, and 1.745 on the other, continue fluid. Sulphuric acid while freezing contracts conſiderably in its dimenſions; ſometimes it forms a confuſed maſs, but often ſhoots into large regular cryſtals in the form of oblique truncated octohedrons, or compreſſed hexahedral priſms, terminated by hexahedral pyramids.

Sulphuric acid unites very eagerly with water. If ſome of the former at the uſual denſity of 1.845 be mixed with ¼ of its weight of water, the temperature of the maſs inſtantly riſes to near 300° Fahr. and a mutual penetration takes place, the denſity of the compound being greater than the mean denſity of its ingredients. If even four parts of ſulphuric acid and one of ice, both at the temperature of 32°, be mixed together, the heat of the maſs will riſe to 212°, but if the proportion of ice be increaſed conſiderably, the caloric neceſſary to the liquid ſtate of the mixture will exceed that which is extricated during the combination of the ingredients, and cold will be produced; thus if four parts of ice and one of acid at 32° be mixed together, the temperature of the maſs will be cooled down to —4°. But in all caſes where concentrated ſulphuric acid is employed in the compoſition of freezing mixtures, there is at the moment of their combination, as Beaumé has well obſerved, a very ſenſible production of heat, which muſt materially diminiſh the frigorific effect; thus according to the able chemiſt laſt mentioned,[f] if one part of ſulphuric acid at the common temperature, and four parts of ice, be mixed together, the firſt effect is to raiſe the thermometer in an inſtant to 94° F. from which it ſinks as ſpeedily to 32°. But if the acid has been previouſly diluted with water, the temperature ſinks on the addition of ice to 5° F. without any previous heat having been excited. So powerful is the affinity of ſulphuric acid for water that it will abſorb moiſture with great rapidity from the air, ſo as in a very few days to double or treble its weight. Even a boiling temperature, when the acid is moderately concentrated, will not counter-balance this ſtrong tendency; hence it is that ſulphuric acid cannot by boiling in an open veſſel, be concentrated nearly ſo much as by diſtillation in a cloſe apparatus.

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[d] Iriſh Phil. Tranſ. vol. iv. p. 88.

[e] Phil. Tranſ. for 1787, p. 267.

[f] Chem. Exper. I. p. 219.

It does not appear poſſible to obtain the ſulphuric acid free from water, except it is combined with ſome alkaline or earthy-baſe; but as it is a matter of ſome importance, both in chemical experiments, and in ſeveral manufacturing proceſſes where this acid is employed, to aſcertain the real ſtrength of mixtures, containing different proportions of acid and water, ſeveral chemiſts have engaged with various ſucceſs in this intereſting enquiry. Upon the whole the experiments of Mr. Kirwan, corrected as they have been by the obſervations of Morveau and Berthollet, ſeem entitled to moſt confidence, and are ſufficiently exact to anſwer every practical purpoſe. The method by which Mr. Kirwan has reſolved this important problem is the following.[g] He took ſome purified cream of tartar, and calcined it in a ſilver crucible till the tartaric acid was entirely deſtroyed; from the reſidue by lixiviation with diſtilled water, he obtained a ſolution of pure ſubcarbonat of pot-aſh, which, after evaporation to dryneſs and ſubſequent ignition, weighed 1523. 5 grs. This ſalt was then diſſolved in water, and the whole weight of the ſolution amounted to 4570 grs. Of this latter ſolution 360 grs., containing 120 grs. of ſubcarbonat of potaſh, were ſaturated with 130 grs. of a ſulphuric acid, the ſpecific gravity of which at 60° F. was = 1.565. During the combination of the ſulphuric acid and the alkali, 34 grains of carbonic acid which had previouſly been combined with the alkali were expelled, therefore the amount of pure potaſh in the ſolution was = 120—34 = 86 grs. Water was now added to the ſolution till it amounted to 3694 grs. of which the ſp. gr. at 60° F. was = 1.013. Next, 45 grs. of ſulphat of potaſh were diſſolved in 1017 grs. of water, and the ſp. gr. of this ſolution was exactly equal to that of the one juſt mentioned; but in this latter ſolution the proportion of ſalt to water was :1:23.6, and the ſpecific gravities of both ſolutions being the ſame, the ſalt in each muſt alſo bear the ſame ratio to the water. Therefore in the former ſolution the amount of ſalt was $= \frac{3694}{23.6} =$ 156.52 grs. now of this, 86 grs. were potaſh, hence the remainder, namely 70.5 grs., were acid in the ſtate of concentration in which it exiſts in ſulphat of potaſh; but ſulphat of potaſh loſes ſcarcely any perceptible weight by ignition, from which it may be inferred that it contains little or no water of cryſtallization, and that it is compoſed of mere or *real* acid and potaſh. Therefore 130 grs. of ſulphuric acid at 1.565 contain 70.5 of real acid, and 100 parts of the ſame diluted acid contain 54.2 of real acid.

By a ſimilar method the proportion of real acid in ſulphuric acid of the ſpecific gravity of 2.0 or *ſtandard* acid was aſcertained, and by diluting this acid with various proportions of water, the quantity of ſtandard or real acid in acid of any ſpecific gravity between 2.0 and 1.0955 was found. But when ſulphuric acid and water are mixed together, a mutual penetration takes place, in conſequence of which there is an increaſe of ſpecific gravity. This augmentation was found to amount to about $\frac{1}{75}$ of the whole denſity. The gravities as found by experiment being corrected accordingly, a table was conſtructed ſhewing the ſpecific gravity of any mixture of ſulphuric acid and water, from the moſt concentrated oil of vitriol, down to one ſo dilute as to contain only 1.78 per cent. of real acid. This table will be given in the Appendix.

The component parts of ſulphuric acid are well known to be ſulphur and oxygen, as may be demonſtrated either by analyſis or ſyntheſis; thus if ſulphur be digeſted with nitric acid, nitrous gas will be given out from the decompoſition of the acid, while the oxygen, the other element, will combine with the ſulphur, and form with it ſulphuric acid; on the other hand, if ſulphat of ſoda be mixed with charcoal, and expoſed to a red heat, the ſulphuric acid is deoxygenated by the ſuperior affinity of the charcoal; carbonic acid and carbonous oxyd are produced, and the ſulphat of ſoda is found to be converted into ſulphuret of ſoda, from which the ſulphur may readily be procured by ſolution in water, and the addition of an acid.

But though the elements of ſulphuric acid are aſcertained, much doubt ſtill exiſts with regard to their relative proportions, we ſhall therefore enter with ſome minuteneſs on this part of the ſubject. Three methods have been followed in attempting to reſolve this important queſtion. The firſt that we ſhall mention, and apparently the moſt direct, was employed by Lavoiſier. He placed a given weight of purified ſulphur in a receiver, with a little water to abſorb the acid produced, then ſetting fire to the ſulphur, he ſupplied it with oxygen gas of known purity, till the combuſtion ceaſed, then by aſcertaining the weight of ſulphur burnt, and of oxygen gas conſumed, he inferred that ſulphuric acid was compoſed of 71 parts ſulphur to 29 parts oxygen. In this eſtimate however the proportion of ſulphur is manifeſtly exaggerated, for by the combuſtion of ſulphur in oxygen gas, a quantity of ſulphurous acid will be produced as well as of ſulphuric, the former of which contains a much greater proportion of ſulphur than the latter.

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[g] Iriſh Phil. Tranſ. vol. iv.

The ſecond method is that by Berthollet, as follows. Having aſcertained that nitre and ſulphur in the proportion of four parts of the former to one of the latter when heated in a retort, re-acted on each other quietly and without exploſion, he mixed together 288 grs. of nitre, and 72 grs. of ſulphur, and heated the mixture in a glaſs retort till the emiſſion of nitrous gas entirely ceaſed: during the proceſs, 12 grs. of ſulphur had ſublimed unaltered, and 228 grs. of ſulphat of potaſh were produced by the combination of the alkaline baſe of the decompoſed nitre with the newly produced ſulphuric acid. Now according to Kirwan, ſulphat of potaſh is compoſed of 45.2 ſulphuric acid, and 54.8 potaſh, therefore out of the 228 grs. of ſulphat of potaſh, 103 grs. were ſulphuric acid, compoſed of 72—12 = 60 grs. ſulphur, and 43 grs. oxygen; hence 100 parts of ſulphuric acid conſiſt of

58.2	Sulphur
41.8	Oxygen
100.0	

The third method, which has been followed by Berthollet, Thenard, and Chenevix, and which appears upon the whole the beſt, is to digeſt a given weight of ſulphur in nitric acid, till it is completely diſſolved and acidified (which if performed with care may be effected without the production of any ſulphurous acid) then to add a ſolution of nitrat or muriat of barytes as long as any precipitate takes place, by which the whole of the newly-formed ſulphuric acid will combine with barytes into an inſoluble ſalt; then to edulcorate and ignite the ſulphated barytes, and from its weight to deduct that of the barytic baſe; the remainder conſequently will indicate the amount of ſulphuric acid produced, from which by ſubtracting the known weight of ſulphur, we get by inference that of the oxygen. But though this mode of proceeding is apparently unexceptionable, yet unfortunately the differences in the quantity of ſulphat of barytes produced, and in the eſtimates of the component parts of this earthy ſalt are ſo prodigious as to throw great uncertainty upon the ſubject. In the experiments of Berthollet,[g] 288 grains of ſulphur being digeſted with nitric acid, 199 grs. remained undiſſolved, therefore 89 grs. were acidified; muriat of barytes being added there was produced 948 grs. of ſulphated barytes, which by ignition was reduced to 920 grains, therefore 100 grs. of ſulphur would have afforded 1033 grs. of ſulphated barytes.

On the other hand, Mr. Chenevix[h] acidified 100 grs. of ſulphur by digeſtion in nitric acid, and by the ſubſequent addition of nitrated barytes obtained 694 grs. of ſulphated barytes.

Laſtly, M. Thenard,[i] by operating in a ſimilar manner, obtained from 100 grs. of ſulphur 720 grs. of ſulphated barytes.

The above differences in the reſults of experiments made by men of acknowledged ſkill in chemical analyſis, are of themſelves ſufficient cauſes of uncertainty, but the difficulty of deciding will be much increaſed when theſe variations are further modified by the different eſtimates of the component parts of ſulphated barytes. According to Klaproth, Withering, and Black, this ſalt contains about 33.33 per cent. of acid. According to Chenevix, it contains 23.5 of acid; and according to Thenard, 25.18 of acid. (See SULPHAT OF BARYTES.

Hence by compounding the above reſults, the 1033 grs. of ſulphated barytes, obtained by Berthollet, indicate the compoſition of ſulphuric acid to be according to

Klapr.	Thenard.	Chenev.	
24.3	37.4	41.2	Sulphur
75.7	62.6	58.8	Oxygen
100.	100.	100.	

The 694 grs. of ſulphated barytes obtained by Chenevix, from the acidification of 100 grs. of ſulphur, indicate the compoſition of ſulphuric acid to be according to

Klapr.	Thenard.	Chenev.	
43.2	57.4	61.5	Sulphur
56.8	42.6	38.5	Oxygen
100.	100.	100.	

And the 720 grs. of ſulphated barytes, obtained by Thenard, indicate the compoſition of ſulphuric acid to be according to

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[g] Encyclop. Method. Art. Acide Vitriolique.

[h] Phil. Tranſ.

[i] An. de Chim. xxxii. p. 266.

Klapr.	Thenard.	Chenev.	
41.8	55.56	59.1	Sulphur
58.2	44.44	40.9	Oxygen
100.	100.	100.	

It has been ſtated by ſome chemiſts that ſulphuric acid is capable of combining with an additional quantity of oxygen, if diſtilled ſlowly with oxyd of manganeſe. This experiment was however repeated without ſucceſs by Vauquelin and Bouvier;[k] ſulphuric acid and oxygen gas came over, acidulous ſulphat of manganeſe remained in the retort, and the ſulphuric acid on examination did not appear to differ in the ſmalleſt circumſtance from common rectified acid.

Muriatic acid gas combines readily, and in conſiderable abundance with ſulphuric acid; the compound acquires a browniſh tinge, and when expoſed to the air emits denſe white fumes of muriatic acid gas, probably mixed with a little ſulphuric acid, as their odour is more pungent and ſuffocating than that of ſimple muriatic acid.

The nitric and ſulphuric acids unite together readily, either by direct mixture or by adding a little nitre to ſulphuric acid. This compound when moderately concentrated has the property of diſſolving ſilver without materially acting on copper; hence it is in conſiderable uſe for recovering the ſilver from clippings and other refuſe of the manufactories of ſilver plate.

Sulphuric acid abſorbs by agitation a conſiderable quantity of red nitrous vapour,[l] and in conſequence acquires a light blue colour. The mixture when expoſed to the air gives out a white vapour. If water is added the great heat that is thereby generated cauſes a very rapid and copious emiſſion of the nitrous vapour, and ſulphuric acid and water alone remain behind.

Sulphuric acid thus impregnated with nitrous vapour after a time becomes nearly colourleſs, and then concretes into ſolid cryſtals; in this ſtate when dropped into water it acquires a green colour, and both the cryſtals and water ſparkle with the ſpontaneous and copious production of nitrous gas. When the cryſtals are ſimply expoſed to heat they melt, emit a denſe red fume, and after the nitrous vapour is thus driven off, the reſidue is common ſulphuric acid.

None of the ſimple combuſtibles appear to have any action on ſulphuric acid at the common temperature, but at a high heat they are all capable of deoxygenating this acid, and reducing it to the ſtate partly of ſulphur, and partly of ſulphurous acid. Thus if ſulphur and ſulphuric acid are boiled together, the acid takes up a ſmall portion of ſulphur, acquires thereby a yellowiſh colour, and the peculiar ſuffocating odour of ſulphurous acid. In like manner if ſulphuric acid is diſtilled off phoſphorus, a large production of ſulphurous acid takes place, and phoſphoric acid remains behind in the retort. Charcoal in the ſame manner deoxygenates this acid. The action of hydrogen upon it is remarkably energetic; if ſome pure ſand moiſtened with ſulphuric acid, be ſtrongly heated in an earthen-ware tube, and at the ſame time expoſed to a ſtream of hydrogen gas, a copious production of ſulphur and water will enſue from a total decompoſition of one part of the acid, and the combination of its oxygen with the hydrogen; accompanied alſo by ſulphurous acid ariſing from an imperfect decompoſition of the other portion of acid. All the common metals except gold and platina alſo decompoſe ſulphuric acid at a boiling heat; the metal is oxydated and the acid is converted into the ſulphurous. But when an acid ſufficiently diluted is made uſe of, thoſe metals that have a powerful affinity for oxygen decompoſe the water in preference to the acid, whence hydrogen gas is given out, while thoſe whoſe affinity for oxygen is weaker, as ſilver and mercury, exert no action either on the acid or water.

Concentrated ſulphuric acid, even when cold, acts in a very ſtriking manner on moſt kinds of vegetable and animal matter; if a piece of paper or ſtraw, for example, be immerſed in ſulphuric acid, the texture of the ſtraw is ſpeedily broken down, it acquires a deep black colour, and is diffuſed through the acid in a ſtate of half ſolution. This phenomenon however does not take place, as is generally ſuppoſed, on account of the reaction of the ſulphuric acid on the carbon and hydrogen, producing ſulphurous acid, but from the ſtrong affinity of the acid for water, in conſequence of which, the oxygen and hydrogen of the vegetable matter, combine together into water, while the carbon is precipitated. But of this we ſhall treat more fully in the article VEGETABLE MATTER.

Sulphuric acid combines with all the metallic oxyds, with the alkalies, and all the earths except ſilex, forming an important genus of ſalts, called in the reformed nomenclature, *Sulphats*, which ſee.

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[k] Ann. Chem. vii. p. 287.

[l] Prieſtley's Exper. Method. iii. p. 144, 156.

The following is the order of the affinities of ſulphuric acid. Barytes, ſtrontian, potaſh, ſoda, lime, magneſia, ammonia, glycine, yttria, alumine, zircon, metallic oxyds.

The uſes of ſulphuric acid are numerous and very important. It is employed in the laboratory in the preparation of the nitric, muriatic, fluoric, phoſphoric, and many other acids; it is a uſeful agent in various proceſſes of chemical analyſis. It is largely uſed in the arts, particularly by the dyer and callico-printer, and is of no ſmall importance as an article of the materia medica.

SULPHURIC ACID, *fuming*, or *Glacial.* In the preceding article we have briefly noticed ſome of the characteriſtic properties of the glacial ſulphuric acid, or that obtained from the diſtillation of calcined ſulphat of iron: we now proceed to relate them more at large, as having been the occaſion of much controverſy among the continental chemiſts, particularly thoſe of Germany. This acid uſed to be, and perhaps is ſtill, prepared at Nordhauſen in Saxony; it is of a dark brown colour, and exhales, when expoſed to the air, abundance of denſe white ſuffocating vapours; its uſual ſpecific gravity is = 1.95. When diſtilled in a glaſs retort, by the time that a ſmall portion has come over, the remaining acid is nearly colourleſs, and of a ſomewhat leſs ſpecific gravity than the entire acid; it no longer exhales any vapours, and except in ſuperior denſity, it does not appear to differ from the common ſulphuric acid. The fluid and vapour contained in the receiver as they cool down gradually to the temperature of the atmoſphere, begin to congeal; the vapour forms radiated cryſtals on the top and ſides of the receiver, while the bottom is occupied with a confuſedly cryſtalline maſs, differing in denſity according to the ſpecific gravity of the acid before diſtillation. Hence it is obvious, that the fuming acid of Nordhauſen, differs from common acid in being mixed or combined with a cryſtallizable ſubſtance more volatile than ſulphuric acid. This ſubſtance was ſuppoſed from its ſuffocating odour to be ſulphurous acid, accordingly, experiments were made by M. Dollfuſs and others, to reſtore the clear rectified acid to its former ſtate, by digeſting it with charcoal, ſawduſt, oil, alcohol, and other deoxydating ſubſtances; but though the acid by this means acquired a browniſh black colour and a ſulphurous odour, it was hardly at all fuming when expoſed to the air; and on diſtillation it afforded a weakly acid ſulphurous liquor, which neither congealed nor emitted white vapours. From the reſults of theſe experiments M. Dollfuſs concluded that the fuming and glacial quality of the Saxon ſulphuric acid was owing to the preſence of a peculiar volatile ſalt.

In order more compleatly to elucidate the matter, a ſeries of experiments was undertaken by M. Morveau. He took 4 lbs. of green vitriol, and by careful calcination reduced its weight to 28 ounces; theſe were put into an earthen-ware retort and diſtilled at the full heat of a reverberatory furnace. When the retort began to grow red, a weak acid came over in drops during about half an hour; the receiver was then changed, and as the heat increaſed, white vapours began to make their appearance. To the receiver was attached a pneumatic apparatus, in order to collect the gas produced, which being examined from time to time it appeared, that during the firſt three hours, little elſe came over than atmoſpheric air, which was then ſucceeded for the next hour and a half by ſulphurous acid gas either pure or at leaſt mixed with no oxygen; by degrees however it became diluted with oxygen gas, and during the next four hours and a half (after which the proceſs was put an end to) a large quantity of oxygen gas was produced, mixed however during the whole time with ſulphurous acid. The fluid in the receiver was of a brown colour, and being expoſed during the night to a temperature of 47° Fah. was found in the morning to be congealed into a ſolid maſs of cryſtals, with the exception of a few drops of a brown liquid.

As ſoon as the receiver was ſeparated from the retort, it was inſtantly filled with white vapours which poured out ſo rapidly as in a ſhort time to fill the whole laboratory; theſe fumes, though ſomewhat ſulphurous, were by no means ſuffocating. A few drops of water being ſprinkled on ſome of the concrete acid, cauſed a hiſſing noiſe like that of a bar of iron plunged in cold water, and the acid immediately melted and entirely loſt its fuming property. If the ſtopper of the veſſel in which the glacial acid is kept be often taken out, the cryſtals at length reſolve themſelves into a brown liquor, and if this is again ſubjected to diſtillation there comes over an acid, at firſt highly ſulphurous, but becoming leſs ſo as the proceſs goes on; no portion however of the diſtilled product is in the leaſt degree fuming or congealable at the common atmoſpheric temperature.

From theſe facts it appears probable that the eſſential difference between the common and glacial acid, is that the latter from the mode in which it is prepared contains a ſmaller portion of water than the former, and that to this is owing both its volatility and property of congelation; it is incidentally mixed with ſulphureous acid, but the preſence or abſence of this, does not appear to be of any material importance.

SULPHATS.

Under this article we ſhall deſcribe the ſalts produced by the union of ſulphuric acid with the alkalies and earths. The metallic ſulphats are deſcribed under the ſeveral metals.

All the ſulphats form cryſtallizable ſalts with theſe baſes, except with alumine, which requires the preſence of potaſh or ammonia to be able to cryſtallize. The ſulphats are ſcarcely decompoſable by heat alone, but when fuſed in contact with charcoal or any carbonaceous matter, they are converted more or leſs compleatly into *ſulphurets*, as has been deſcribed under that article. They are all inſoluble in pure alcohol. The ſolutions of theſe ſalts are decompoſed by the other ſalts of barytes entirely, and by the ſalts of lime nearly ſo, the acid forming a precipitate with theſe earths. A ſimilar decompoſition takes place when any ſulphat is added to the ſoluble ſalts of lead, ſilver, and other metals whoſe ſulphats are little ſoluble. None of the ſulphats are entirely decompoſed at a moderate temperature by any other acid, the ſulphuric ſtanding the higheſt in the order of affinity, with a very few exceptions. But ſome of the acids partially decompoſe the ſulphats, and by taking part of their baſe they reduce the remainder to the ſtate of acid ſulphats. The nitric and muriatic acids are of this kind, and the tartareous, with regard to the ſulphat of potaſh. But the acids that are fixed in the fire, ſuch as the boracic, phoſphoric, and arſenic, decompoſe the ſulphats totally in a red heat long continued.

SULPHAT OF POTASH, or *Vitriolated Tartar*.

This ſalt may be formed by the direct combination of ſulphuric acid and potaſh, or carbonat of potaſh, but being of little value it is never prepared in this way, as it is produced in the diſtillation of nitric acid, being the reſidue of the decompoſition of nitre by ſulphuric acid. This reſidue, which is a hard, white, acid, ſaline maſs, contains ſulphat of potaſh, generally with a little nitrous acid or with an exceſs of ſulphuric acid. It ſhould be diſſolved to ſaturation in boiling water, nearly ſaturated with carbonat of potaſh, in caſe the acid is in conſiderable exceſs, and on cooling gradually the ſulphat of potaſh ſeparates in ſmall cryſtals. The whole cryſtalline maſs taken out after the liquor is perfectly cold, and has ſtood at reſt for a day, is nothing but ſulphat of potaſh, which by re-ſolution in warm water, and cooling more gradually, may be obtained in larger cryſtals. The form of this ſalt is generally that of a ſix-ſided priſm terminated by as many pyramids, like that of a quartz cryſtal.

Sulphat of potaſh is the leaſt ſoluble of all the ſulphats, requiring about fifteen times its weight of cold water, but only five parts of boiling water, ſo that much of it readily ſeparates from the hot ſolution when ſaturated. The ſalt is very hard and readily reducible to powder, and its taſte is ſaline and bitter. It is perfectly permanent in the air, neither deliqueſcing nor efferveſcing.

On account of the ſparing ſolubility of this ſalt it is often ſeparated in the form of a precipitate from watery ſolutions as ſoon as it is formed. Thus if moderately concentrated ſulphuric acid be added to a ſtrong ſolution of potaſh or carbonat of potaſh, the mixture becomes almoſt immediately thickened with a large quantity of hard white powder which is the ſulphat of potaſh formed and precipitated at the moment of mixture.

This ſalt is one of the moſt eaſily diſtinguiſhable of the ſaline ſubſtances, by its hardneſs, little ſolubility, and bitter taſte, and general pyramidal form of its cryſtals.

When a cryſtal of ſulphat of potaſh is ſuddenly heated it decrepitates, and ſplits aſunder with ſome violence. It then parts with its water of cryſtallization which is not more than 1.4 in 100, according to Dr. Thomſon. At a red heat it melts, but does not undergo further alteration.

According to Mr. Kirwan, 100 parts of the dry decrepitated ſalt, conſiſt of 54.8 of potaſh, and 45.2 of acid, which agrees very nearly with the experiments of Dr. Black; and 100 grs. of the ſalt diſſolved in water, and precipitated by muriated barytes give 135.25 grs. of ignited ſulphat of barytes. But on the other hand, Dr. Thomſon,[a] found that 100 parts of the cryſtallized ſalt loſt 1.4 by fuſion, which is therefore the water of cryſtallization, and that the reſidue diſſolved in water and precipitated by muriated barytes gave only 128 parts of ſulphat of barytes, inſtead of 135.25. The quantity of ſulphuric acid indicated by a given quantity of *ſulphat of barytes* is differently eſtimated as will be mentioned under that head, but the difference between 128 and 135.25 grs. in an experiment performed by two able chemiſts, as appears, preciſely in the ſame way, is not very accountable, particularly with ſo fixed a ſubſtance as ſulphat of barytes, which may be deſiccated thoroughly with ſo little riſk of loſs.

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[a] Syſtem of Chemiſtry.

Acid Sulphat of Potaſh.

If common ſulphat of potaſh is put into a glaſs, or better, a platina veſſel, and ſulphuric acid poured upon it, and heat applied, the maſs firſt melts into an uniform denſe limpid fluid, which when it has arrived at the heat at which ſulphuric acid boils, ſends forth an abundance of white vapour, which is the exceſs of acid that evaporates. This continues till the quantity of acid left in the veſſel is ſomewhat more than a third of the weight of the ſulphat; but when it approaches this point, the vapour gradually diminiſhes and nearly ceaſes, provided the heat does not exceed that of low redneſs, the ſaline maſs in the veſſel remaining all the time perfectly fluid and limpid. It then has the appearance of a very denſe tranſparent oil, and if removed from the fire, it ſpeedily ſolidifies uniformly and compleatly, and becomes a hard, tough opake-white or greeniſh-white maſs of a ſtriated texture, which is the *ſuper-ſulphat of potaſh*. If the veſſel is returned to the fire, the ſalt again melts quietly, and becomes tranſparent. If the heat is raiſed to full redneſs, the evaporation of the acid again begins, and by continuing the heat long enough, and with ſufficient intenſity, all the exceſs of acid may be driven off, and the neutral ſulphat alone will remain; but the difficulty of evaporation increaſes as the exceſs of acid leſſens, ſo that it would require many hours of pretty ſtrong heat to drive off all the exceſs. The fuſibility of the maſs alſo decreaſes as the acid evaporates.

The ſuper-ſulphat thus obtained (the heat not having exceeded a low redneſs) has a ſtrongly acid taſte mixed with ſomewhat of bitterneſs. It is much more ſoluble in water than the ſulphat, requiring for ſolution no more than twice its weight of water when cold, and leſs than its own weight when boiling. It is very ſlightly deliqueſcent. If moiſtened with a very little water and melted, on cooling it forms a ſofter maſs than before, compoſed of long ſtriæ, ſomewhat flexible, and often of a ſilky luſtre. The ſaturated ſolution of this ſalt in boiling water cryſtallizes on cooling.

Super-ſulphat of potaſh is decompoſed by thoſe ſubſtances that decompoſe the ſulphat, and it is alſo reduced to the ſtate of common ſulphat by any alkali or earth, which unites with the exceſs of acid. The proportions of its conſtituent parts are only uniform when it is cryſtallized, and it is then compoſed of about two parts of ſulphat of potaſh, and one of ſulphuric acid.

The neutral ſulphat is highly uſeful in the manufacture of *Alum*, and a little in medicine. The ſuper-ſulphat is not employed, as it is not produced in any manufacture, and neither of theſe ſalts are of ſufficient value to be worth preparing by the direct combination of their ingredients.

SULPHAT OF SODA, or *Glauber's Salt.*

This ſalt was firſt diſcovered by Glauber, in 1658, in the reſidue of the diſtillation of common ſalt and ſulphuric acid for procuring muriatic acid. This ſalt and Epſom ſalt, or ſulphat of magneſia, were often confounded together for ſome time after the firſt diſcovery of each, till the real nature of the latter was aſcertained by Dr. Black.

Sulphat of ſoda is found native in a variety of places and both ſolid and diſſolved in natural waters, but on the whole the quantity is but ſmall. The native *Glauber's ſalt* is found in Hungary, in the neighbourhood of ſalt lakes, and is deſcribed under this article. This ſalt is alſo contained in greater or leſs quantity in almoſt every natural water that has any ſaline taſte or quality, ſuch as the Seltzer, Cheltenham, &c. and particularly in many of the hot ſaline ſprings, combined with carbonat of ſoda, of which the celebrated thermal waters of Carlſbad are ſtriking inſtances, and are eſtimated by fair calculation to pour out annually upwards of a million of pounds of this ſalt along with other ingredients. Many brine ſprings alſo contain this ſalt, which remains in the mother water after the extraction of the common ſalt, and may then be obtained by evaporation and cryſtallization on cooling.

Glauber's ſalt is alſo procured in many proceſſes of chemical manufacture, either as a reſidue, or an intermediate product in the preparation of ſoda. A good deal of it is obtained in manufacture as a reſidue in the diſtillation of muriatic acid from ſulphuric acid and common ſalt, or of oxymuriatic acid from ſulphuric acid, common ſalt, and manganeſe; or in the manufacture of *ſal ammoniac* from ſulphat of ammonia and common ſalt, which laſt in this country furniſhes the greater part of the Glauber's ſalt in uſe.

This ſalt is alſo obtained by the decompoſition of *muriat of ſoda* by pyrites, and by gypſum, (as deſcribed under that article) and is the intermediate ſtep in the manufacture of ſoda from common ſalt.

Sulphat of ſoda in its common ſtate forms long tranſparent cryſtals, which are uſually ſix-ſided priſms with dihedral ſummits. Sometimes they are obtained of an enormous ſize, nearly a foot in length, and an inch in breadth, but commonly their length is from one to about three inches. The taſte of ſulphat of ſoda is ſalt, bitter, and unpleaſant. The cryſtals are ſoluble in leſs than three times their weight of cold water, but at a boiling heat no water is required, as they readily liquefy in their water of cryſtallization. Hence this ſalt is one of thoſe that cryſtallizes with the greateſt eaſe from a hot concentrated ſolution. Conſiderable cold is produced during the ſolution of the cryſtals in water. When the cryſtals are heated they liquefy in their water of cryſtallization, and if the heat is continued till the water is entirely evaporated, a hard white ſaline maſs remains, which is the ſalt unaltered except by the loſs of water, ſo that on re-ſolution it is obtained in cryſtals as before. If the dry ſaline maſs be boiled with water till the latter is fully ſaturated, and the ſolution poured into a thin phial whilſt yet ſcalding hot, and immediately corked perfectly tight, the liquor does not ſolidify on cooling if kept quite at reſt, but remains fluid and tranſparent. But on opening the cork, and, if neceſſary, giving the bottle a gentle ſhake, an inſtant ſolidification begins at the ſurface, rendering it opake, and proceeds rapidly downwards to the bottom till the whole is compleatly congealed, and may be inverted without ſpilling a particle. A ſenſible warmth is felt on the outſide of the bottle at the time of congelation. The cauſe of this is the extrication of the caloric of liquefaction, as explained under the article *Caloric*, p. 207.

When this ſalt in its cryſtallized ſtate is expoſed to a dry air it ſoon becomes covered with a mealy-looking powder, and after a time the whole falls into the ſame white powder, which conſiſts of the ſalt merely deprived of moſt of its water of cryſtallization by the action of the air, and reduced to about half its former weight. Hence the ſalt ſhould be kept in well-cloſed bottles to preſerve its cryſtalline form.

The compoſition of this ſalt may be inferred from the following facts. According to Klaproth,[b] 1000 grs. of the ſalt recently cryſtallized and dried on blotting paper were reduced by thorough drying on a ſand-bath to 420 grains, whence the quantity of water of cryſtallization is 58 per cent. Alſo 100 grs. of the dried ſalt diſſolved in water, and decompoſed by acetited barytes gave 168 grs. of dry ſulphat of barytes, whence 42 grains of dry Glauber's ſalt (the quantity contained in 100 of the cryſtallized ſalt) would give 70.56 grains of ſulphat of barytes.

Laſtly, from the reſpective quantities of ſulphuric acid and ſoda required for mutual ſaturation, and from the quantity of dry ſulphat of ſoda thereby produced, Mr. Kirwan eſtimates the proportions of ingredients in 100 parts of the cryſtallized ſalt to be 58 of water, 23.52 ſulphuric acid, and 18.48 ſoda.

Some of the decompoſitions of ſulphat of ſoda by other ſalts are intereſting. Of theſe the moſt curious is that of the formation of this ſalt in a mixture of ſulphat of magneſia and muriat of ſoda, when expoſed to a freezing temperature, which was firſt remarked by Gren.[c] Theſe ſalts do not decompoſe each other in a temperature above freezing, but do it readily and almoſt compleatly below this point. What is remarkable, this decompoſition when once effected is permanent at any temperature, for on raiſing the heat, Epſom ſalt and common ſalt are not regenerated as might have been expected.

Sulphat of ſoda is decompoſed by muriat of lime, and as the ſulphat of lime thence reſulting is nearly inſoluble, moſt of it precipitates, and the ſolution contains little elſe than the regenerated muriat of ſoda, provided the quantities of each ſalt have been duly proportioned to each other. When muriated magneſia and ſulphat of ſoda are in ſolution together, the addition of lime cauſes the following ſucceſſive decompoſitions, viz. the lime firſt decompoſes the muriated magneſia, muriat of lime is formed and pure magneſia is precipitated; and the muriat of lime thus formed then decompoſes the ſulphat of ſoda, and muriat of ſoda remains in ſolution, whilſt ſulphat of lime precipitates and mixes with the magneſia, which has before ſubſided. It is upon theſe two circumſtances, namely, the decompoſition of muriated magneſia by lime, and of Glauber's ſalt by muriated lime, that Gren has propoſed an ingenious method of ſeparating the deliqueſcent earthy muriats from brine, and increaſing the proportion of common ſalt, by the addition of lime, or Glauber's ſalt, or both, according to the following caſes:

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[b] Eſſays, vol i. p. 282.

[c] An. Chim. tom. 24.

1. If the brine contains, beſides common ſalt, only muriated lime, the addition of Glauber's ſalt is ſufficient, which by decompoſing the calcareous muriat produces ſelenite and common ſalt, as already mentioned.
2. If the lime contains, beſides common ſalt, Glauber's ſalt and muriated magneſia, the addition of lime alone will ſuffice, which, as we have before deſcribed, firſt decompoſes the muriated magneſia, and the reſulting muriat of lime then decompoſes the Glauber's ſalt.
3. If the brine contains, beſides common ſalt, only muriated magneſia, both lime and Glauber's ſalt muſt be added, for obvious reaſons.
4. If the brine contains, beſides common ſalt, ſulphat and muriat of magneſia, lime and Glauber's ſalt muſt alſo be added.
5. If the brine contains, beſides common ſalt, ſulphat and muriat of magneſia, and ſulphat of ſoda, lime alone will be ſufficient if the Glauber's ſalt be in ſufficient quantity, if not, an additional quantity of the latter ſalt muſt alſo be added.

We know not whether any of theſe methods have been adopted in the manufacture of ſalt in the large way, neither would they be required in the Engliſh rock ſalt and brine works on account of the very ſmall proportion of impurities, and which do not appear to throw much obſtacle to the goodneſs of the ſalt, but in the ſalterns from ſea-water, where the ſalts of lime and magneſia are abundant, the ingenious ideas of Gren might be adopted to advantage. The greateſt objection would be in the coſt of Glauber's ſalt, but it might be probably collected in winter, from ſulphat of magneſia and common ſalt, at a moderate expenſe, and from the remaining muriat of magneſia, the earth might then be precipitated by a carbonated alkali.

Sulphat of ſoda is largely uſed in medicine, being a very uſeful, powerful, and cheap purgative. It is no otherwiſe uſed in manufacture than as a material from which the ſoda may be extracted by any of the methods already deſcribed under the article muriat of ſoda.

When ſulphat of ſoda is diſſolved in dilute ſulphuric acid and ſet aſide to cryſtallize, it depoſits large rhomboidal cryſtals,[d] which contain an exceſs of acid, and are therefore a *ſuper ſulphat of ſoda*.

If dry ſulphat of ſoda is heated in a glaſs or platina veſſel with concentrated ſulphuric acid, they melt together as the mixture of ſulphat of potaſh and ſulphuric acid do, but the acid in this caſe is readily driven off by a moderate continuance of heat, and the remaining ſalt rediſſolved in water, yields cryſtals of common Glauber's ſalt.

But a mixture of equal parts of ſulphat of potaſh and ſoda retain an exceſs of ſulphuric acid almoſt as obſtinately as ſulphat of potaſh alone does. In all theſe caſes the exceſs of acid may be got rid of moſt accurately, without affecting the neutral ſalt, by diſſolving the whole in water, ſuperſaturating it with carbonat of ammonia, evaporating the mixture carefully to dryneſs, and then applying a moderate red heat. A denſe white ſmoke ariſes before the mixture is red-hot, which is ſulphat of ammonia, and by continuing the heat as long as a particle of viſible ſmoke riſes, all the exceſs of acid is volatilized along with the ammonia, and the neutral ſulphat of potaſh or ſoda, remains perfectly pure, white and dry. It is probable however that a ſmall portion of the neutral ſalt would be found to have been volatilized along with the ſulphat of ammonia, but this loſs can only be very ſmall, and the actual quantity might be eaſily aſcertained by a few comparative experiments.

SULPHAT OF AMMONIA. *Glauber's Secret Sal-Ammoniac.*

This ſalt has not been found native. It may be prepared by ſaturating moderately dilute ſulphuric acid with ammonia, and evaporating conſiderably. It then cryſtallizes on cooling, in hexahedral priſms terminated by hexahedral pyramids, or often in ſilky needled cryſtals. This ſalt is produced in the manufacture of ſal-ammoniac, but only as an intermediate product, and is immediately decompoſed by common ſalt, producing Glauber's ſalt and muriated ammonia.

Sulphat of ammonia is very ſoluble in water, requiring only twice its weight of cold, and much leſs of boiling water. This ſalt is very ſlightly deliqueſcent in the air. It generates much cold during ſolution.

When a quantity of this ſalt is heated *per ſe* in a retort, and all the products received in ſucceſſion,[e] it firſt liquefies and mere water comes over, after which a conſiderable quantity of ammoniacal gas is given out, and if the ſalt in the retort be then examined, it is found to be ſulphat of ammonia with exceſs of acid, and may be diſſolved in water and cryſtallized with this exceſs, forming a *ſuper-ſulphat*. But if the heat is continued, after the ammonia has paſſed over there riſes a denſe white cloud which fills the veſſels and concretes into minute glittering cryſtals of volatilized ſuper-ſulphat. After this riſes a great quantity of ſulphurous acid and water, the greater part of which condenſes in the receiver, and with them a quantity of *azotic gas*, all of which continue till nothing remains in the retort. During the diſtillation the contents of the retort are always liquid, and when the proceſs is over, the receiver contains ſulphurous acid, water, and ammonia, and in the neck of the retort is a quantity of ſublimed ſuper-ſulphat of ammonia.

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[d] Thomſon.

In the above proceſs ſeveral decompoſitions take place. At firſt a part of the ammonia ſeparates from the ſalt leaving the latter with exceſs of acid; after which, as the heat is increaſed, part of the ſuper-ſulphat in the retort is totally decompoſed, the ammonia is reſolved into its elements, azot and hydrogen, the former of which paſſes off in a gaſeous form, and the hydrogen unites with part of the oxygen of the ſulphuric acid to form water, and the acid with a diminiſhed quantity of oxygen becomes ſulphurous acid. The entire products therefore are ammonia, water, ſulphurous acid, together with ſome ſuper-ſulphat that has eſcaped compleat decompoſition.

All the other ammoniacal ſalts ſuffer this decompoſition of the alkali, totally or in part, when expoſed to a high heat.

Sulphat of ammonia is decompoſed by the fixed alkalies and by the alkaline earths. Its compoſition according to Kirwan, is 14.24 per cent. of ammonia, 54.66 of acid, and 31.1 of water.

Sulphat of Barytes.

The native ſulphat has been already deſcribed under the article *Heavy Spar*, and it appears to agree very exactly in chemical compoſition with the artificial ſulphat, for if any given weight of heavy ſpar be decompoſed by a carbonated alkali, and the carbonated barytes thence ariſing be diſſolved in muriatic acid, and again precipitated by ſulphuric acid in the form of a ſulphat, the weight of the latter very exactly correſponds with that of the native ſulphat if pure, and if an equal degree of heat has been employed in the deſiccation.

Sulphat of barytes is formed whenever any barytic ſalt comes in contact with ſulphuric acid in any combination, and being perfectly inſoluble in water, and in all acids, except the moſt concentrated, it precipitates totally and ſpeedily in all common caſes, and may be collected, edulcorated, and dried with great eaſe, and without riſk of loſs. It is then quite free from ſmell and taſte.

Sulphat of barytes is the heavieſt of all the earthy ſalts. It undergoes no change by being heated red-hot, without addition, except the loſs of the water which it may contain. In a very ſtrong fire and before the blow-pipe it melts into an opake milky globule.

This ſalt is perfectly unchanged by any expoſure to air. None of the acids when at all dilute have any effect upon it, but if it is heated with concentrated ſulphuric acid to the boiling point of the acid, it diſſolves therein compleatly, forming a clear colourleſs denſe fluid.[f] On dilution with water the ſulphat of barytes again ſeparates totally and unchanged. The ſulphuric ſolution expoſed to the air for ſome days depoſits the ſulphat of barytes in beautiful radiated cryſtals, and this is the only method in which it can be brought to cryſtallize by art. This is doubtleſs effected by the abſorption of water from the atmoſphere, which dilution being gradual allows the ſulphat to be ſeparated in a regular form.

No ſingle agent, neither acid, nor alkali, nor earth, can ſeparate the ſulphuric acid from barytes except perhaps the fixed acids ſuch as the arſenic and fluoric, in a very ſtrong heat, but this ſulphat is readily decompoſed by double affinity by the carbonated fixed alkalies; and alſo by fuſion with charcoal. In the former caſe the decompoſition may be effected either by repeatedly boiling the ſulphat in fine powder, with a ſolution of carbonat of potaſh and ſoda, or by mixing the ſulphat with two or three times its weight of the dry carbonated alkali, and giving the mixture a moderate red heat (which need not be urged to fuſion) for half an hour, and then lixiviating the ſaline maſs.

In both inſtances a ſaline ſolution is formed, which conſiſts of ſulphat of potaſh or ſoda with ſome undecompoſed alkaline carbonat, and an inſoluble powder is obtained, which conſiſts of carbonated barytes with any ſulphat of barytes that may have eſcaped decompoſition, and which may be readily ſeparated by the nitric, muriatic, or acetic acids, which diſſolve the carbonat and leave the ſulphat.

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[e] Hatchett, Phil. Tranſ. for 1796. p. 315.

[f] Withering, Phil. Tranſ. for 1784.

In the other method, ſulphat of barytes is decompoſed by fuſion with about a ſixth of charcoal, and ſulphuret of barytes is formed, from which the earth is then readily ſeparated by nitric or any other acid.

Sulphat of barytes is alſo decompoſed by fuſion with muriat of lime.

All theſe methods are more fully deſcribed under the article *Barytes*. (p. 124.)

Though barytes or any of its ſoluble ſalts are highly poiſonous, its ſulphat has no obvious effect on the body when taken into the ſtomach.

The compoſition of ſulphat of barytes has been very variouſly eſtimated. Kirwan, Klaproth, Black, and ſome other eminent chemiſts, reckon it to be compoſed of about two parts of barytes and one of ſulphuric acid, or 33.3 per cent. of acid and 66.6 of earth, when heated long enough to expell all the adhering moiſture. On the other hand Mr. Chenevix eſtimates only 23.5 per cent. of acid and 76.5 of barytes. As the authorities on each ſide are of the higheſt reſpectability, and as the eſtabliſhment of this point is of more importance than perhaps of any other compound, on account of the frequency with which it is reſorted to in chemical operations, it will be right to give the particulars of each mode of eſtimation, which are in many reſpects eſſentially different.

Dr. Withering in his analyſis of the native carbonat of barytes diſſolved 100 grains of this ſubſtance in muriatic acid, then decompoſed it by dropping in ſulphuric acid till no more precipitate enſued, and the latter, after edulcoration and ignition for half an hour in a *red heat*, weighed 117 grains. In another experiment, 50 grs. of the carbonat gave 58.4 grs. of the ſulphat, which cloſely correſponds with the former. Now he had before found that 100 grains of the carbonat, previouſly dried in a red heat, and then diſſolved in muriatic acid, loſt 21 grs. by effervefcence, which was therefore carbonic acid, and contained 78.6 grs. of pure barytes. Hence as 100 grs. of the carbonat give 117 of the ignited ſulphat it may be concluded that theſe 117 parts are compoſed of 78.6 of barytes and 38.4 of acid, or, that 100 parts of the ſulphat of barytes conſiſt of about 67.2 of barytes, and 32.8 of acid.

The experiments of Klaproth,[g] very cloſely agree with thoſe above mentioned. This accurate chemiſt found by analyſis, that 100 grains of witherite, or native carbonat of barytes, contained 78 of barytes, and that the ſame quantity of it diſſolved in muriatic acid, and precipitated by the ſulphuric gave 120.5 grs. of ſulphat of barytes *dried in air*, which may be reckoned as equal to 117.2 grs. of the ſame when *fully ignited*; for he ſays in another place,[h] that 185 grs. of ſulphat dried in air were reduced to 180 by ignition. This eſtimation therefore would give 66.55 of barytes, and 33.55 of ſulphuric acid in 100 of the dry ſulphat.

Nearly the ſame quantity of acid alſo is found indirectly by decompoſing an alkaline ſulphat by a barytic ſolution. Dr. Black found in his analyſis of the Geyſer waters, that 100 grs. of fully dried Glauber's ſalt formed 170 grs. of dry ſulphat of barytes; and Klaproth[i] alſo found the ſame quantity of Glauber's ſalt to produce 168 grains of ſulphat of barytes. Now by Mr. Kirwan's experiments,[k] 100 grs. of dry Glauber's ſalt contain 56.08 of real ſulphuric acid, whence the proportion in 100 of ſulphat of barytes would be 32.98 in Dr. Black's experiment, and 33.38 in Klaproth's. The Glauber's ſalt alſo that Klaproth employed contained in 132.5 grains all the dry ſulphuric acid of 95 grs. of liquid acid of 1.85 ſp. gr. which by Mr. Kirwan's eſtimation is 77.18 grs. of real acid, and therefore amounts to 56.9 grs. in 100 of ſulphat of ſoda, a number ſufficiently near to 56.08 to confirm the general accuracy of the experiment.

From all theſe experiments therefore we are led to conclude that dry ſulphat of barytes contains very nearly two-thirds of barytes, and one-third of acid, or 66.6 per cent. of the former, and 33.3 of the latter.

On the other hand the experiments of Mr. Chenevix[l] on this ſubject include two objects, one to aſcertain the quantity of ſulphur in ſulphuric acid, and the other to determine the compoſition of the ſulphats of barytes and lime. They were as follows: 100 parts of ſulphur were put into a retort with nitric acid, and a receiver with a Woulfe's apparatus was luted on. The acid was repeatedly diſtilled off the ſulphur till the whole was diſſolved, and converted into ſulphuric acid, and the nitrous gas generated in the proceſs was paſſed through water to abſorb any ſulphurous acid if generated, but none of this was found. All the liquors in the apparatus were united, and nitrat of barytes was added as long as any precipitate appeared, which was therefore ſulphat of barytes, and amounted when dry to 694 grs. Two other experiments gave nearly the ſame reſults, whence the author concludes the quantity of ſulphur in 100 parts of ſulphat of barytes to be 14.5 grs.

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[g] Analyt. Eſſays, vol. i. p. 232—237.

[h] Ibid. p. 376.

[i] Ibid. p. 282.

[k] Addit. Obſerv. on Mineral Acids.

[l] Iriſh Acad. Tranſ. for 1802, or Phil. Mag. vol. 5.

In the next place ſome pure lime was prepared by ſaturating muriatic acid with white marble, precipitating the lime as a carbonat by carbonated potaſh, and fully calcining the carbonat of lime in a platina crucible, in a violent heat, till the weight no longer diminiſhed. Of this lime, 100 grains were diſſolved in dilute muriatic acid in a platina crucible, and then ſufficient ſulphuric acid was added which precipitated ſulphat of lime. The whole contents of the crucible were evaporated to dryneſs, then raiſed to ſuch a temperature as would expell every thing but the combined ſulphuric acid. The increaſe of weight thus obtained was 76 grs. whence the author concludes 176 parts of dry ſulphat of lime to contain 76 of real ſulphuric acid, ſo that this ſalt will then conſiſt of 57 per cent. of lime and 43 of acid. Hence, by knowing the ratio that ſulphat of barytes bears to ſulphat of lime, the quantity of ſulphur in ſulphuric acid may be aſcertained. For this purpoſe 100 grs. of the ſame dried ſulphat of lime (at 43 per cent. of acid) were attempted to be diſſolved in water alone, but finding that an inconvenient bulk of fluid would be required in this way, Mr. C. firſt added ſome oxalic acid to the ſulphat, and then a little muriatic acid, which effected a compleat ſolution in a moderate quantity of fluid.

The ſolution therefore contained oxalat of lime, probably with a little ſuper-ſulphat, both of which were diſſolved in muriatic acid.

Into this liquor muriat of barytes was poured as long as any precipitate fell down, and the liquor was heated for a ſhort time to keep in ſolution any oxalat of barytes which would be formed, and which is eaſily ſoluble in an exceſs of acid. The weight of the ſulphat of barytes was (on the average of three experiments) 183 grs. which therefore, contain as much acid as 100 grs. of the ſulphat of lime employed, or 43 grs. and hence 100 parts of ſulphat of barytes will contain 23.5 of acid. But by the firſt experiment, 100 parts of ſulphat of barytes were formed by the acidification of 14.5 grs. of ſulphur, and hence the 23.5 parts of ſulphuric acid are eſtimated to be compoſed of 14.5 of ſulphur and 9. of oxygen, ſo that 100 parts of dry ſulphuric acid muſt conſiſt of 61.5 of ſulphur and 38.5 of oxygen. Alſo, if ſulphat of barytes contains only 23.5 per cent. of acid, the whole of the remainder, or 76.5 muſt be barytes.

To recapitulate the reſults of theſe experiments —

Sulphuric acid is compoſed of

61.5	Sulphur
38.5	Oxygen
100.0	

Sulphat of lime, perfectly deſiccated, is compoſed of

57.	Lime
43.	Sulphuric acid
100.	

Sulphat of barytes, perfectly deſiccated, is compoſed of

		76.5	Barytes
Sulphur	14.5	23.5	Sulphuric acid
Oxygen	9.0		
		100.0	

100 parts of ſulphat of lime contain the ſame quantity of acid as 183 parts of ſulphat of barytes.

The diſagreement between the experiments of Mr. Chenevix and thoſe of Klaproth, Withering, and other chemiſts already mentioned, is much too great to be accounted for from ſlight variations in deſiccation, &c. and we muſt acknowledge they are unaccountable. Some obſervations may be made on this ſubject.

Firſt, as to the proportion of barytes in the ſulphat eſtimated by Mr. C. This able chemiſt infers it from the quantity of acid produced, and attempts to account for the difference between his and former calculations, by obſerving that "at the time when the experiments "were made that determined the proportion of "33 per cent. of acid in ſulphat of barytes it "was not known that we had never obtained "barytes pure, and that a conſiderable portion "of carbonic acid reſiſted the action of every "degree of heat that had been applied to carbonat of barytes," &c.

But the experiments that determined the above proportion of 33 per cent. were made by decompoſing the carbonat, not by heat, but by an acid, and the loſs of about 22 per cent. of carbonic acid by effervescence was confirmed in Klaproth's experiments by many unexceptionable proceſſes. If therefore, as we have before mentioned, 100 parts of the pure carbonat loſe nearly 22 of carbonic acid by effervescence, and produce 117 of the ſulphat (which is a ſimple and apparently unexceptionable experiment) the quantity of 76.5 per cent. of barytes in the ſulphat muſt be largely overrated; for if 100 of the ſulphat contain 76.5, 117 will contain 89.5 of barytes, which is obviouſly incompatible with the other experiments, as the 100 parts of carbonat could not contain more earth than 78 at the utmoſt, when it loſt 22 by effervescence.

Mr. Chenevix produced 694 of ſulphat of barytes by acidifying 100 grs. of ſulphur with nitric acid, and precipitating all the liquors by nitrat of barytes; which is in the proportion of 14.5 of ſulphur in 100 of the ſulphat. But if 100 of ſulphat of barytes contain 66.6 of earth and 33.3 of acid, the compoſition of ſulphuric acid would be as 14.5 of ſulphur to 18.8 of oxygen, which is double the higheſt eſtimation of oxygen, and obviouſly impoſſible. Can a quantity of nearly inſoluble nitrat have mixed with the ſulphat and increaſed its weight?

In Mr. Chenevix's next experiment the 43 parts of ſulphuric acid contained in 100 of ſulphat of lime, produced 183 of ſulphat of barytes. According to Klaproth's analyſis of this latter ſulphat 43 parts of acid ſhould only have produced three times as much ſulphat of barytes, or 129 parts. The method employed by Mr. C. was rendered complex by the introduction of oxalic acid, yet it does not appear that it would involve any material ſource of error. But on the other hand, Klaproth[m] eſtimates that 220 of ſulphat of barytes are equivalent in acid to 160 of ſulphat of lime, whence 100 of the latter would yield by decompoſition 137 of ſulphat of barytes. It ſhould alſo be obſerved that Mr. Chenevix makes a much lower eſtimaation of the quantity of ſulphuric acid in ſulphat of lime than Kirwan, Klaproth, and other chemiſts do; for by Mr. Chenevix, 57 of lime and 43 of acid conſtitute 100 of the ſulphat, but by the other eſtimation 100 parts of perfectly dry ſelenite, contain about 40 of lime and 60 of acid.

The diſagreement of theſe experiments performed by chemiſts of acknowledged ſkill and fidelity, might lead to the ſuppoſition of there being more than one ſpecies of artificial ſulphat of barytes, with different proportions of acid and earth, but further experiments are required to determine this point.

A moſt unexceptionable method of aſcertaining the quantity of barytes would be the following: diſſolve ſome of the pureſt tabular cryſtals of muriated barytes in water, decompoſe the ſolution by carbonated ammonia, waſh the precipitated carbonated barytes, and dry it for half an hour in a low red heat. Take a given quantity of this carbonat, ſaturate it with muriatic acid, and note the loſs of carbonic acid, decompoſe the ſolution by ſulphat of ſoda, edulcorate the barytic ſulphat, and dry it in a low red heat for half an hour, and weigh it. Then take another equal or aliquot portion of the carbonat of barytes, diſſolve it in the pureſt nitric acid, evaporate the ſolution to dryneſs, and gradually ignite the nitrat in a clean platina crucible till all the acid is decompoſed and driven off, and the pure barytes alone is left.

The results of theſe experiments compared together, would give as accurately as can well be done, the quantity of carbonic acid, and of barytes in the carbonat, and of barytes in the ſulphat.

Sulphat of Lime. *Selenite. Gypſum.*

Under the article *Gypſum* the different ſpecies of the native ſulphat of lime are deſcribed. To this it may be added that this ſalt is moſt extenſively diffuſed over the earth, being found in ſmall quantity in almoſt every common ſpring water to which it gives (in common with other earthy ſalts) the properties of hardneſs or harſhneſs to the feel, and of curdling ſoap.

Sulphat of lime when taken into the mouth in ſubſtance is almoſt entirely deſtitute of taſte, owing to its very difficult ſolubility. It requires for ſolution about 500 parts of cold water, and ſomewhat leſs of boiling water, ſo that it is partly depoſited from the hot ſaturated ſolution on ſtanding for ſome hours. Though the quantity of ſulphat of lime in ſolution in pure water is ſo ſmall, each of its ingredients may be formed into ſtill leſs ſoluble ſalts, and a precipitate will appear on the addition either of oxalic acid which abſtracts the lime, or of a barytic ſalt which unites with the acid.

Sulphat of lime is rendered much more ſoluble in water by the addition of any acid, all of which (the oxalic excepted) ſimply diſſolve without decompoſing it unleſs the quantity of acid be very large.

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[m] Vol. i. p. 168.

[n] Kirwan's Addit. Obs.

On evaporating any of the ſolutions of ſelenite in acids, and allowing the ſolution to cool when highly concentrated, this ſalt ſeparates in long tranſparent cryſtals, which is a very common form for it to occur in chemical analyſes. It is then diſtinguiſhed by its want of taſte, its difficult ſolubility when removed into pure water, and by its affording a precipitate with the oxalic and barytic ſalts. When a liquor containing ſelenite is rapidly evaporated, this ſalt ſeparates as a brittle ſhining pellicle.

When the cryſtallized ſulphat of lime, native or artificial, is calcined in a red heat, it ſplits, and falls into a mealy powder by the loſs of its water of cryſtallization. This forms the plaſter of Paris ſo much employed in modelling and cements, as it has the property when mixed with water to the conſiſtence of a thin paſte, of ſolidifying in a few minutes, and becoming a hard brittle maſs.

Selenite, like all the other ſulphats, is inſoluble in alcohol, and hence this fluid is a very uſeful teſt to detect the preſence of ſelenite in any watery ſolution, and to ſeparate it without decompoſition. Mr. Kirwan[*] found the power of this teſt to be ſo extenſive that ſelenite may be compleatly precipitated from water that contains it in the proportion of $\frac{1}{1000}$, or even leſs, by any ſpirit of wine whoſe ſpecific gravity is below 0.850. Hence much advantage may be made of alcohol in analyſes of compounds that contain this ſalt.

Sulphat of lime is decompoſed by the fixed alkalies, by lime, and by barytes, eſpecially in a boiling heat, and ſtill more readily by the alkaline carbonats. For this purpoſe reduce the ſulphat to fine powder and boil it for a quarter or half an hour, with twice its weight of dry carbonat of potaſh or ſoda diſſolved in water, and a compleat decompoſition will be effected, the liquor will contain ſulphat of potaſh or ſoda, and at the bottom will be the lime of the ſelenite, fully carbonated, from which the pure lime may be procured by compleat calcination in a platina crucible, or the proportion of lime may be eſtimated from the known conſtituent parts of the artificial carbonat, which, when dried and ignited, contains 55 per cent. of lime.

Sulphat of lime when expoſed to a very intenſe heat melts into an opake white vitreous maſs. When heated with charcoal, it is partially and imperfectly decompoſed, and ſome ſulphuret is formed.

The compoſition of ſulphat of lime is given with ſome variety, by different chemiſts.

Mr. Kirwan found that 439 grs. of a dilute ſulphuric acid (compoſed of 225 grs. of ſtrong acid of 1.5654 ſp. gr. at 60° mixed with 225 grs. of water) ſaturated 152 grs. of marble, which contained 83.6 grs. of lime. The above quantity of dilute acid contained 119.5 of *real acid* (for the explanation of which ſee the article Sulphuric Acid) and conſequently the acid and lime are to each other as 119.54: 83.6 or as 58.84 of acid to 41.15 of lime. But it is ſcarcely poſſible to obtain theſe quantities from 100 parts of ſelenite, unleſs after very long and violent ignition, on account of the obſtinacy with which water adheres to the ſalt. This circumſtance too throws ſome difficulty in the analyſis of this ſalt, for if 100 parts, for example, be merely ignited for a ſhort time, and the lime ſeparated accurately, if the entire weight remaining to make up the 100 parts be conſidered as real acid, it would give too high a proportion of the latter, ſince ſelenite thus dried generally contains at leaſt 5 or 6 per cent. of water.

Thus Klaproth obtained 26.5 grs. of ignited carbonat of lime from 40 grs. of ignited ſelenite, which would be equivalent to 36.87 of pure lime from 100 of the ſelenite; but if all the 63.13 remaining were conſidered as real acid, it would probably make it much too high.

The eſtimation given by Mr. Chenevix of the proportions of ſulphuric acid and lime in the ſulphat very ſtrongly ignited, and the mode of making the experiment, have been already mentioned in the preceding article of *Sulphat of Barytes*. Dr. Thomſon,[p] on repeating Mr. C's experiment obtained widely differing reſults, being 56 of acid and 42 of lime, whereas, Mr. C. obtained 43 of acid and 57 of lime. As Dr. Thomſon's experiment much more cloſely coincides with thoſe of Kirwan, Klaproth, Bergman, and Wenzel, we cannot help conſidering it as more correct, or at leaſt as more approaching to the point of mutual ſaturation of the acid and baſe. From all that has been done, however, it is clear that when this ſulphat occurs in chemical analyſis it is not ſafe to eſtimate its compoſition from any aſſumed proportions, but it ſhould be decompoſed by boiling with an alkali in the way already mentioned, by which the quantity of lime may be aſcertained; and if that of the ſulphuric acid be wanted, it muſt be obtained by converting it to a ſulphat of barytes, having previouſly ſaturated the exceſs of alkali by muriatic acid.

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[*] On Mineral Acids.

[p] Syſtem of Chemiſtry, vol. ii. p. 355.

There does not appear to be any proper *ſuperſulphat* of lime, an exceſs of acid only rendering the ſulphat more ſoluble, and it cryſtallizes from its acid ſolution in its common neutral ſtate.

SULPHAT OF STRONTIAN.

This ſalt has been found native in England, near Briſtol; in Pennſylvania; and more lately near Paris. It has already been deſcribed under the article *Cœleſtine*.

Sulphat of ſtrontian is a ſalt without taſte and ſmell. It is nearly inſoluble in water, but not abſolutely ſo, for Klaproth found that a pound of water boiled on a quantity of this ſulphat diſſolved about 3 grains. It is not decompoſed by any ſingle acid; but barytes, alone or in combination, takes from it its acid, with which barytes has the greater affinity. Sulphat of ſtrontian is alſo decompoſed by the carbonated fixed alkalies, and with much more eaſe in the moiſt way than the ſulphat of barytes. Sulphat of ſtrontian, like the barytic ſulphat, is readily ſoluble in ſulphuric acid, and precipitable thence by dilution with water. This ſalt is decompoſed by fuſion with charcoal into a ſulphuret.

The analyſis of the native ſulphat has been undertaken by Klaproth,[q] by Vauquelin,[r] and by Mr. Clayfield the diſcoverer of it in this country,[s] and the reſults of theſe chemiſts have a very cloſe agreement.

The method to be followed in theſe analyſes is very ſimple. Reduce a given quantity of it to fine powder, digeſt it in a warm temperature with a few ounces of dilute muriatic acid, which will ſeparate any iron, lime, or ſulphat of lime which it may contain, but will not touch the ſulphat of ſtrontian; then boil the inſoluble reſidue for an hour with thrice its weight of very pure carbonat of potaſh diſſolved in water, which will effect a compleat decompoſition, the ſulphuric acid of the ſalt will remain in ſolution with the potaſh, and a bulky white powder will ſubſide which is carbonat of ſtrontian. The quantity of ſulphuric acid is to be aſcertained by firſt ſuper-ſaturating the ſolution with muriatic acid, and then adding muriat or acetite of barytes as long as any precipitate falls down, which is barytic ſulphat, and ſhould be waſhed, dried, ignited, and weighed. The carbonat of ſtrontian remaining may be immediately waſhed, dried, and ignited, and from its weight that of the ſtrontian may be inferred; but to be certain that all the ſulphat of ſtrontian has been decompoſed, it will be better to rediſſolve the carbonat in dilute nitric or muriatic acid (by which any undecompoſed ſulphat will be left behind) and precipitate it by carbonated ammonia at a boiling heat, after which the carbonated earth may be dried. If any admixture of ſulphated barytes is ſuſpected, which is ſeldom the caſe, proceed as above, but inſtead of finally decompoſing the muriatic ſolution of the earth by carbonated ammonia, evaporate it to the cryſtallizing point, when, after ſtanding for a time, the *muriat of barytes* will appear in its proper form of white opake tabular cryſtals, whereas the *muriat of ſtrontian* ſeparates in needled cryſtals, which latter may be further diſtinguiſhed by giving a red colour to the flame of alcohol.

With regard to the reſults of the different analyſes, Klaproth found that 100 grs. of the ſulphat decompoſed in the manner above-mentioned, produced 124 grs. of ignited ſulphat of barytes, and 82 grs. of carbonated ſtrontian. The ſulphuric acid of the former he reckons as a third of the weight, or about 42 grs.; and the pure ſtrontian of the latter at 58 grs. having found by former experiments that 100 grs. of ignited carbonat of ſtrontian loſt 30 grs. of carbonic acid by efferveſcence, and that the remaining 70 per cent. were (to a trifling reſidue) pure ſtrontian.

A hundred parts of pure ſulphat of ſtrontian therefore will contain according to this eminent chemiſt, nearly,

Real ſulphuric acid —	42 grs.
Strontian — — —	58
	100.

The analyſis of Vauquelin is ſo far imperfect that it only goes to aſcertain the quantity of ſtrontian in the ſulphat. By his experiments 167 parts of the ſulphat gave 129 parts of the carbonat, which (following Klaproth's proportions) would give 54 of ſtrontian in 100 of the ſulphat.

Laſtly, Mr. Clayfield, whoſe analyſis ſeems conducted with care and ſkill, and who aſcertained both the quantity of earth and of acid, gives the compoſition of this ſulphat almoſt exactly the ſame as that of Klaproth. He alſo aſſerts that the artificial ſulphat contains 2 per cent. more acid than the natural.

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[q] Anal. Eſſays.

[r] Journ. des Mines, tom. 7, No. 37.

[s] Nicholſon's Journal, 4to. vol. 3, p. 337.

Sulphat of Magnesia. *Epſom Salt. Bitter Purging Salt.*

This uſeful ſalt is occaſionally found native, but by far the greater part is artificially prepared.

The native ſalt when ſolid is met with almoſt invariably in the form of fine capillary cryſtals, on the ſurface of decompoſing ſchiſtus, often in coal-pits, and not unfrequently effloreſcing on the ſurface of the ſoil. A very pure ſulphat of this kind is deſcribed under the article Bitter Salt (*which ſee*) and was found in the mercury mines of Idria where it is known under the name of *Haarſalz*, and was miſtaken for plumoſe alum till Klaproth detected its real nature.

Fontana mentions[t] a large quantity of this ſalt found in the quarries of gypſum in Piedmont effloreſcing on the ſurface of the gypſum (particularly in thoſe that are the moſt expoſed to the ſun,) which is bruſhed off from time to time, and when diſſolved in water and cryſtallized is ſold by the peaſants.

Prouſt[u] alſo relates that this ſalt abounds ſo much in many parts of Spain, that in Andaluſia large tracts are covered with an effloreſcence of it after floods; and in moſt of the houſes of Madrid, the foundation and lower walls are covered with this ſalt, which ariſes from the decompoſition of the mortar, to the great detriment of the buildings.

It is not unfrequent to meet with the ſame ſalt in this country, forming a fine hair-like ſaline covering to the walls of damp cellars, or new buildings. An effloreſcence of this kind is noticed by Dr. Boſtock[v] on the walls of a new houſe near Liverpool, which was very pure ſulphat of magneſia; and a ſimilar production of this ſalt is mentioned by Mr. Gregor,[w] on the ſurface of a wooden frame uſed to ſift coal-aſhes, which latter on analyſis were found to contain gypſum along with ſulphat of magneſia. In many of theſe inſtances the ſulphat of magneſia appears to ariſe from a decompoſition of ſulphat of lime by magneſia, but the preciſe mode in which this apparent contradiction to the known order of affinities is brought about, is not very apparent. In other caſes the pyrites commonly contained in coal appears a principal agent in the production of this ſalt, for Mr. Gregor obtained it in abundance by calcining for an hour a mixture of about two parts of pyrites with one of ſteatite, and after long expoſure to air, lixiviating the calcined maſs.

It is probable that many of the natural ſaline effloreſcences which have been ſuppoſed to be native ſaltpetre, may contain ſulphat of magneſia.

Another ſource of this ſalt is in certain ſaline ſprings, and it is from theſe that our firſt knowledge of it originated.

It was firſt diſcovered at Epſom in Surrey, by Dr. Grew, in the year 1675, in a mineral water, to which it gave conſiderable celebrity, and the ſalt itſelf was extracted by boiling, and was ſold at a high price as Epſom ſalt. The ſame ſalt was ſometime afterwards found in a well at Shooter's Hill in Kent, in the year 1700, which was alſo extracted by boiling down, and was ſold as Epſom Salt.

A few years afterwards it was found by ſome chemiſts that the ſame ſalt could be prepared from the *bittern* or mother water of ſea-water, after all the muriat of ſoda had been extracted in the uſual method, and which uſed to be thrown away. This proceſs was long kept as a lucrative ſecret in the hands of a few ſalt-makers, and the ſulphat of magneſia made at the brine works at Portſmouth and Lymington being afforded much cheaper than could be done by the evaporation of the mineral waters of Epſom or Shooter's Hill, the latter gradually fell into diſuſe, and for many years almoſt all the vitriolated magneſia uſed in this country has been prepared at the ſalt works at Lymington.

This ſalt was long conſidered as peculiar to this country, and large quantities were exported into other parts of Europe, and ſold under the name of *Engliſh or Epſom Salt*. It was afterwards diſcovered in the mineral water of Seydſchutz or Sedlitz in Bohemia, whence it alſo obtained the name of this water, the celebrated Hoffman having ſhewn its identity with the true Epſom ſalt. Sulphat of magneſia was long confounded with ſulphat of ſoda, and though ſufficient marks of diſtinction were given by many practical chemiſts, the true nature of the Epſom ſalt was not fully underſtood till Dr. Black, in 1755, ſhewed, in the moſt convincing manner, that it conſiſted of magneſia, combined with the vitriolic acid, and obtained the magneſia from it by means of an alkali.

This confuſion of the two ſalts was further promoted by a fraud commonly practiſed on the Continent (where the Engliſh or Epſom ſalt was ſold at a high price) of ſubſtituting for it Glauber's ſalt, made by ſtirring a warm ſaturated ſolution of it till nearly cold, whereby it ſeparated in ſmall needled cryſtals, very cloſely reſembling the form of the true Epſom ſalt. On the other hand, when Glauber's ſalt was the moſt in requeſt in this country, the Epſom ſalt makers uſed to obtain the latter ſalt in large cryſtals imitating the ſulphat of ſoda, by adding an exceſs of ſulphuric acid, and probably by a ſlower evaporation. Both theſe ſalts were occaſionally called in medicine *Sal Mirabile*, and as the medicinal effect was the ſame, this alſo further contributed to keep up the miſtake. The diſtinction between the two is now known to be perfectly ſimple, for the addition of any carbonated fixed alkali will immediately render a ſolution of ſulphat of magneſia turbid, but will not alter the tranſparency of ſulphat of ſoda. The ſolution ſhould be ſomewhat diluted.

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[t] Journ. de Phyſ. tom. 33, p. 312.

[u] Ibid. tom 32, p. 247.

[v] Phil. Journ. vol 3.

[w] Ibid. vol. 5.

The method of preparing ſulphat of magneſia, from the bittern of ſea-water, has been variouſly ſtated. It is ſtrongly affirmed by ſome, that no addition is made to it, but that the whole proceſs is merely that of evaporating the liquor to a very high point of concentration, and on cooling, the ſulphat cryſtallizes, which is purified by a ſecond ſolution and cryſtallization. On the other hand it is ſtated, (and, we muſt acknowledge, with much more probability) that ſulphat of iron, or the mother water of vitriol, or ſulphuric acid, in ſome form or other, is added to the bittern. If Bergman's analyſis of ſea-water is correct, this addition is neceſſary; for, according to this eminent chemiſt, ſea-water contains, in the Engliſh wine pint, 186.5 grains of muriat of ſoda, 51 grs. of muriated magneſia, and 6 grs of ſulphat of lime. Therefore, as during the evaporation only muriat of ſoda, with part of the ſulphat of lime, are ſeparated, the *bittern*, or reſidue after the ſalt has been chiefly extracted, muſt contain a large quantity of muriat of magneſia, ſome common ſalt, and only a very ſmall portion of ſulphat of lime; and, conſequently, an addition of ſulphuric acid, in ſome form or other, is required to decompoſe the magneſian muriat.

Sulphat of magneſia has a ſalt and bitter taſte, followed, when taken in quantity, with a ſlightly ſweetiſh flavour. The regular form of this ſalt is a four-ſided priſm, terminated by four-ſided pyramids; but it is only obtained regular by the ſlow and inſenſible evaporation of a ſaturated ſolution. In general it is in the form of ſmall white needled cryſtals, produced by the cooling of the hot ſaturated ſolution. The common ſulphat is conſiderably deliqueſcent, but this is probably owing to the admixture of ſome muriat of magneſia or lime; for the large regular cryſtals of this ſulphat are permanent in the air, and ſomewhat effloreſce when the atmoſphere is dry and warm.

This ſalt is extremely ſoluble in water. The preciſe degree of ſolubility in ſome meaſure depends on its purity: the pure ſalt diſſolves in nearly its own weight of cold water, and by increaſing the heat much more is taken up. The ſalt, when heated alone, melts in its own water of cryſtallization, of which it contains about 48 per cent,[x] after which it becomes a hard opake maſs, which will bear a very ſtrong heat without melting or parting with any of its acid; ſo that it is again equally reſoluble in water. In a very intenſe heat, or before the blow-pipe, it melts into an opake maſs.

This ſalt is not decompoſed by any ſingle acid. When the fixed alkalies are added to its ſolution, the magneſia is ſeparated pure; but with the carbonated fixed alkalies, *carbonat of magneſia* is precipitated, as has been deſcribed under that article.

There does not appear to be any proper *ſuperſulphat of magneſia*, though the very large cryſtals of this ſalt are ſaid to be made by ſlowly cryſtallizing the ſolution with exceſs of acid. If ſulphuric acid is added to dry ſulphat of magneſia, the whole of the exceſs of acid is volatilized at a low red heat, without difficulty.

The action of ammonia or its carbonat, on this ſalt, will be mentioned in the next article.

Sulphat of magneſia, when well cryſtallized, is eſtimated by Bergman to contain 19 per cent. of magneſia, 33 of real ſulphuric acid, and 48 of water. Mr. Kirwan eſtimates that 100 parts of the ſalt, when perfectly dried at a ſtrong heat, contain 36.68 of magneſia, and 63.32 of acid, which very cloſely agrees with the eſtimation of Bergman.

Sulphat of magneſia is frequently, in the courſe of chemical analyſis, mixed with ſulphat of lime, and often with ſulphat of iron, and the ſeparation of theſe ſalts is of importance in coming at accurate reſults. Several methods may be uſed. The following will ſeparate the iron: if the mixture of theſe ſalts be in ſolution, and any caſual exceſs of acid has been ſaturated, the addition of ſuccinat of ammonia will precipitate the iron, and leave the earthy ſalts untouched: or elſe the mixed ſalts may be dried and calcined for an hour in a red heat, by which the acid will be expelled from the ſulphat of iron, and the ſulphat of lime alſo will be rendered ſcarcely ſoluble, whilſt the affuſion of cold water, and digeſtion for ſome hours, will completely diſſolve out the ſulphat of magneſia. If only the latter ſalt and ſulphat of iron were preſent, the only inſoluble reſidue will be the brown colcothar, or oxyd of iron, belonging to the ſulphat, and from which the quantity of the latter may be eſtimated.

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[x] Bergman on Magneſia.

The Sulphats of lime and of magneſia may be ſeparated in two methods. If the magneſian ſalt is very ſmall in proportion to the other, the addition of perfectly cauſtic ammonia will ſeparate the magneſia (though not totally) and leave the lime untouched, provided the mixture be kept for ſome hours in a well corked bottle, to exclude the carbonic acid of the atmoſphere. But as it is more commonly required to ſeparate ſulphat of lime from a larger quantity of ſulphat of magneſia, advantage is taken of the very difficult ſolubility of the former and the ready ſolubility of the latter. The mixed ſolutions therefore are to be concentrated highly by evaporation; when, after ſome hours repoſe, moſt of the ſulphat of lime will ſeparate alone, and may be removed. The ſolution may then be evaporated to dryneſs and ſtrongly calcined, and then pulverized and digeſted with three or four times its weight of cold or lukewarm water, by which the whole of the magneſian ſulphat will be diſſolved, and what little ſulphat of lime may remain after the firſt proceſs, will remain untouched. The ſolution may then be boiled with carbonat of potaſh, to decompoſe the carbonat of magneſia, and the latter, when waſhed, dried, and ignited in a ſtrong red heat till it is fully calcined, will be pure magneſia. We may add, that when calcined magneſia contains any lime, it may be eaſily detected by rubbing a quantity of it with ſome diſtilled water, putting the whole in a phial, and ſhaking the mixture frequently during digeſtion for a few hours. On ſubſidence, the clear liquor will be a *lime-water*, if any lime be contained in the magneſia, as may be diſcovered by its becoming turbid on blowing through it with the breath, or adding a few drops of a carbonated alkali; but if the magneſia be pure, the water will have diſſolved nothing.

Sulphat of magneſia is largely uſed in medicine, both directly and for the preparation of *Magneſia* and its *Carbonat*, the methods of procuring which have been deſcribed under theſe articles.

AMMONIACO-MAGNESIAN SULPHAT.

When pure ammonia is added to ſulphat of magneſia, a great part of the earth is precipitated, but the reſt remains in ſolution, and, by evaporation, a triple ſalt, compounded of ſulphuric acid, magneſia, and ammonia, is formed. This ſalt is alſo procured more ſpeedily, and with leſs loſs, by adding to a ſolution of ſulphat of magneſia one of ſulphat of ammonia, each ſomewhat concentrated. An abundant depoſition of regular, tranſparent, ſhining cryſtals takes place immediately, which are the triple ſalt in queſtion. The form of this ſalt is generally octohedral[y]: its taſte is ſalt and bitter. When heated, it firſt melts in its own water of cryſtallization, after which it is decompoſed, ammonia is firſt given out, then acidulous ſulphat of ammonia riſes, and ſimple ſulphat of magneſia remains.

This triple ſalt is much leſs ſoluble in water than either of the ſulphats of which it is formed, as is obvious by its precipitating on the addition of the two ſolutions. It is compoſed, according to Fourcroy, of 68 per cent. of ſulphat of magneſia, and 32 of ſulphat of ammonia.

SULPHAT OF ALUMINE.

The ſimple combination of ſulphuric acid and alumine, was often produced in the reſearches of the various eminent chemiſts who have turned their attention to the analyſis and manufacture of alum; but a more accurate knowledge of it is due to Vauquelin. Under the article *Alum*, we have fully detailed the many intereſting experiments that have been made on this valuable ſalt, and given the proofs of the neceſſity of potaſh and ammonia to its compoſition.

Sulphat of alumine, therefore, differs from alum in not containing any alkali, and on this account it is ſcarcely cryſtallizable.

Sulphat of alumine is made by diſſolving pure alumine in equally pure ſulphuric acid, at a boiling heat, evaporating the ſolution to compleat dryneſs, and then re-diſſolving the reſidue in water. In this ſtate, if the previous deſiccation has been compleat, an aſtringent ſolution is obtained, which is not ſenſibly acidulous, and by haſty evaporation only gives a ſaline magma; but when evaporated ſlowly, and with great care, it may be made to appear in the form of ſoft, flexible, ſhining cryſtalline plates. But if a few drops of potaſh, or any ſalt of potaſh, be added to the ſolution, the alkali unites to the ſulphat of alumine, and almoſt immediately a quantity of (comparatively) large hard octohedral cryſtals of alum are depoſited. The proportion of potaſh neceſſary to produce a ſenſible quantity of alum is ſo ſmall, that all the common ſulphuric acid of the ſhops will give it; and hence the pure ſulphat of alumine muſt be made with rectified ſulphuric acid, and very pure alumine.

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[y] Fourcroy.

Sulphat of alumine is infuſible in any heat, but when ſtrongly urged in the fire, it parts with its acid altogether.

An *Acidulous*, or *Super-ſulphat of Alumine*, is formed by diſſolving the latter ſalt in ſulphuric acid. It is then cryſtallizable with ſtill more difficulty, and the ſalt is ſenſibly acid and auſtere to the taſte. It depoſits cryſtals of alum ſtill more readily on adding potaſh than the neutral ſulphat does, as alum is naturally a ſalt with exceſs of acid.

The ſuper-ſulphat of alumine may be reduced to the neutral ſulphat by long boiling with alumine, but with difficulty. Neither of theſe ſalts is uſed.

SULPHURIZED MURIATIC ACID.

Sulphur, when expoſed to the long-continued action of oxymuriatic acid, is converted into ſulphuric acid, as we have already mentioned; but when the oxygenation of the ſulphur is not compleated, the reſult is a ſingular compound, the properties of which have hitherto been only examined by Dr. Thomſon.[a] It is thus prepared: charge a retort with common ſalt and oxyd of mangaueſe; annex to it a Woulfe's apparatus, with two or three bottles; put ſome dry flowers of ſulphur into the firſt bottle, and into the next ſome carbonated potaſh, to abſorb the ſuperfluous acid: then pour into the retort ſome concentrated ſulphuric acid, and oxymuriatic acid gas will be immediately liberated. After the ſulphur has been for ſome time in contact with this gas, it will become moiſt and doughy, its colour will change to orange, by degrees it will become more and more ſoft, and at length will be reſolved into a red fluid: as ſoon as this is effected, the proceſs muſt be ſtopped.

The liquid thus obtained is perfectly clear, of a colour between ſcarlet and crimſon, by reflected, and green by tranſmitted light; its ſpecific gravity is $= 1.62$, and its weight is more than twice that of the ſulphur employed. When firſt expoſed to the air it ſmokes like the diſtilled muriat of tin, but after a time its fumes are not more copious than thoſe from ſtrong muriatic acid. It is very volatile at a moderate temperature. Its odour reſembles that of ſea-weed, but is much ſtronger, and it affects the eyes in the ſame manner as wood ſmoke does. Its taſte is acid, hot and bitter. It changes paper ſtained with vegetable blues to red, but not very rapidly, unleſs water is added.

If a drop of ſulphurized muriatic acid be let fall into a glaſs of water, the ſurface is immediately covered with a thin film of ſulphur, and a greeniſh red globule falls to the bottom, which remains for ſome time like a drop of oil, but is at length converted into acid flakes, of a yellow colour, which are very ductile, even after long expoſure to the air. A ſimilar yellow matter is precipitated from the ſulphurized muriatic acid, on the addition of a weak ſolution of potaſh: this matter is hot to the taſte, and adheres to the finger like thick oil paint. By digeſtion in hot water it is converted into common ſulphur, and the water becomes acidulous from the preſence of muriatic and ſulphuric acids. Solid muriat of barytes, whether cryſtallized or in fine powder, affords no precipitate with the entire ſulphurized acid, whence it appears that it contains no ſulphuric acid; but this latter makes its appearance whenever water is added: it is probable therefore that the whole of the ſulphur, when combined with the muriatic acid, is in the ſtate of oxyd, but the addition of water determines the whole of the oxygen to unite with part of the ſulphur, converting it into ſulphuric acid, while the remainder of the ſulphur is deoxydated.

If this ſulphurized acid is poured into warm nitric acid, a violent effervеſcence, accompanied by a kind of exploſion, takes place; but if it is dropped very ſlowly into cold nitric acid, only a moderate effervеſcence takes place. Nitrous gas and oxymuriatic acid gas are evolved, and the ſulphur is acidified.

Sulphurized muriatic acid, even when cold, diſſolves phoſphorus very readily; no effervеſcence happens, and the ſolution acquires a bright amber colour. If this ſolution is mixed with cauſtic potaſh, the whole maſs becomes beautifully luminous, and ſulphur in combination with phoſphorus is precipitated.

When mixed with alcohol, a violent effervеſcence enſues, and ether is diſengaged.

Nitric acid decompoſes this ſulphurized acid, without occaſioning any precipitate. Sulphurous acid appears incapable of decompoſing it, but all the other acids throw down from it a quantity of ſulphur. The fixed alkalies, when dry, produce with it a violent effervefcence, and a conſiderable degree of heat. If ammoniacal gas is thrown into it, the veſſel is ſoon filled with a purple vapour, and the liquor becomes ſolid, and of a deep red colour; but when mixed with water it ſpeedily diſſolves, and ſulphur is precipitated. This ſingular ſubſtance has not yet been very exactly analyzed; indeed it appears to be by no means uniform in its compoſition: in one ſpecimen Dr. Thomſon found the relative proportions of muriatic acid and oxyd of ſulphur to be as 44. of the latter to 35. of the former. In another ſpecimen the proportions were 47.1 muriatic acid, 35.2 oxyd of ſulphur, and 4. ſulphuric acid. The oxyd of ſulphur appears to be compoſed of 93.8 ſulphur, and 6.2 oxygen.

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[a] Nich. Journ. 8vo. vol. vi. p. 104.

SULPHUROUS ACID. *Acide Sulfureux.* Fr. *Schwefeligte Saure,* Germ.

The ſuffocating vapour that riſes during the combuſtion of ſulphur, is ſulphurous acid, and although ſome of its moſt obvious properties muſt have been known from time immemorial, yet the firſt chemiſt who appears to have examined it with any attention was Stahl. This eminent philoſopher named it *phlogiſticated vitriolic acid,* becauſe he conſidered it as differing from common vitriolic acid only in containing a larger proportion of phlogiſton or the principle of inflammability: he alſo ſhewed that it might be combined with potaſh, by dipping a cloth in a ſolution of this alkali, and expoſing it, while yet moiſt, to the vapour of burning ſulphur. Scheele made ſome additions to our knowledge of this ſubſtance, which was ſtill further extended by the important diſcoveries of Dr. Prieſtley. Next, Berthollet inveſtigated the properties of this acid and its ſalts, with his accuſtomed ſagacity. The accuracy of Vauquelin, in conjunction with Fourcroy, enlarged ſtill further our acquaintance with this ſubſtance; and, finally, we are indebted to Dr. Thomſon, for the beſt analyſis of it that has yet been publiſhed, and for the diſcovery of ſome intereſting facts, which had been overlooked or obſcurely ſtated by preceding inquirers.

There are two ways of procuring ſulphurous acid; namely, by the combuſtion of ſulphur, or by the partial decompoſition of ſulphuric acid. The firſt of theſe methods, although apparently very ſimple, is in fact the moſt troubleſome; for if the combuſtion is performed by atmoſpheric air, the newly-formed acid mixes with the residual azotic gas; from which it is incapable of being directly ſeparated. If, on the other hand, oxygen gas is made uſe of, not only ſulphurous but ſulphuric acid is produced, and part of the oxygen remains mixed with the ſulphurous acid gas. Hence it is that, for chemical experiment, this acid has always been procured by the decompoſition of ſulphuric acid.

Various ſubſtances have been employed for this purpoſe, ſuch as wood, charcoal, oil, alcohol, and other vegetable ſubſtances and products: all theſe, however, are more or leſs objectionable, as both carbonic acid and gaſſeous oxyd of carbon are given out together with the ſulphurous acid. Sulphur itſelf has been made uſe of, and the only objection is the ſlowneſs with which the acid is thus produced. Dr. Prieſtley firſt employed the metals, inſtead of the more compound combuſtibles. He found that iron and zinc, being metals ſo greedy of oxygen as to decompoſe water, were by no means ſo proper for this purpoſe as copper, ſilver, or mercury; ſince in the former caſe the acid was mixed more or leſs with hydrogen, proceeding, no doubt, from the decompoſition of the water which common ſulphuric acid contains.

Sulphurous acid gas is thus prepared: pour into a narrow necked glaſs retort two parts, by weight, of concentrated ſulphuric acid, and one of mercury; dip the beak of the retort under mercury, and then apply a lamp or a pan of charcoal: when the acid gets warm, it will begin to act on the mercury, and bubbles of gas will be diſengaged: as ſoon as the common air of the veſſel is driven out, and is ſucceeded by bubbles of white ſuffocating vapour, an inverted jar, filled with mercury, may be placed over the beak of the retort, and will thus be ſpeedily filled with gas. This gas is ſulphurous acid in its pureſt ſtate, and exhibits the following properties. It is inviſible, colourleſs, and elaſtic, like common air; it has an extremely pungent ſuffocating odour, and is incapable of ſupporting either combuſtion or animal life. Its ſpecific gravity is about = 0.0025, or ſomewhat more than twice as great as that of atmoſpheric air. It is acerb and ſour to the taſte, reddens moſt blue vegetable juices, and, after a time, deſtroys the colour of many of them. It does not appear ſuſceptible of any change by mere heat; but, according to an experiment by Monge and Clouet, if expoſed at the ſame time to great preſſure and a cold equal to 31° Fahr. it loſes its elaſticity, and aſſumes a liquid ſtate. Water, by ſimple expoſure to an atmoſphere of this gas, without agitation or extraordinary preſſure, abſorbs, according to Prieſtley,[b] about 44 times its bulk, or $\frac{11}{100}$ of its weight; and according to Thomſon, at 61° Fahr. 33 times its bulk, or $\frac{8.25}{100}$ of its weight; but if water be ſaturated with this gas, by means of a Woulfe's apparatus, the bottles of which are ſurrounded with ice, it will be found to have taken up, according to Vauquelin,[c] about $\frac{15}{100}$ of its weight. The ſpecific gravity of this liquid acid is ſtated by Berthollet at 1.04, and by Vauquelin at 1.02; by Thomſon at 1.05 at 68°.

Oxygen gas appears to have no action on ſulphurous acid gas, when both the ingredients are dry; but if to a mixture of one part of the former and two of the latter, there be added a very little water, a ſudden diminution of bulk will at firſt take place, owing to the abſorption of part of the acid gas by the water; after which a further gradual abſorption happens, in conſequence of an actual combination going on between the two gaſſes, by which ſulphuric acid is formed and part of the oxygen gas diſappears. It is aſſerted by Fourcroy, that if a mixture of oxygen and ſulphurous acid gaſſes are paſſed through a red hot tube, ſulphuric acid is formed by their combination: in this caſe, however, it is probable that the gaſſes were previouſly ſaturated with water; for it is perfectly well aſcertained, that during the diſtillation at a high red heat of calcined ſulphat of iron, there comes over, beſides ſulphuric acid, a mixture of ſulphurous acid and oxygen gas, which may be readily ſeparated from each other by means of a dilute alkaline ſolution, which detains the former, but allows the latter to paſs through unaltered.

Oxymuriatic acid gas is readily decompoſed by ſulphurous acid; the veſſel becomes filled with white vapours, and a mixture of ſulphuric and muriatic acids is the reſult.

Hydrogen gas and ſulphurous acid exerciſe no action on each other at the common temperature, but if a mixture of three parts, by bulk, of the former, and one of the latter, are made to paſs through a red hot glaſs tube, the ſulphurous acid is totally decompoſed, and the products are ſulphur, water, and ſometimes a little ſulphuretted hydrogen.

Phoſphorus, even when ſtrongly heated in a glaſs tube, appears to have no action on ſulphurous acid gas. Phoſphuretted hydrogen, on the contrary, even at the common temperature, readily decompoſes this acid; the mixture loſes its ſtate of elaſtic fluidity, a white vapour makes its appearance, and the ſides of the veſſel are lined with a mixture of ſulphur and phoſphorus. Sulphuretted hydrogen has a ſimilar effect to phoſphuretted hydrogen, and ſulphur is precipitated from the decompoſition both of the acid and of the inflammable gas.

Charcoal, at the common temperature, imbibes a conſiderable quantity of ſulphurous acid gas, but appears to produce no material change upon it: at a red heat, however, the gas is decompoſed, ſulphur is depoſited, and ſulphuretted hydrogen is produced; the hydrogen, doubtleſs, originating from the water either of the acid gas or of the charcoal.

With camphor, ſulphurous acid combines readily, and the reſult is a liquid, the properties of which have been but little inveſtigated: this compound, when dropped into water, depoſits again the camphor, which appears to have undergone ſcarcely any alteration.

Sulphuric acid, eſpecially at a low temperature, abſorbs a large proportion of ſulphurous acid gas: the combination ſoon becomes ſolid, and in this ſtate it has but little odour; but if a portion be laid on a piece of glaſs and expoſed to the air, it preſently reſolves into a liquid, at the ſame time diſengaging, with a very viſible efferveſcence, the greateſt part of the ſulphurous gas. Strong and colourleſs nitric acid, by being impregnated with ſulphurous acid gas, acquires a deep orange tinge, and nitrous gas is diſengaged; the ſulphurous being at the ſame time converted into ſulphuric acid.

Water, when ſaturated with ſulphurous gas, forms the liquid ſulphurous acid: it is beſt prepared in a Woulfe's apparatus, with two or more bottles, into the firſt of which ſhould be put a little water, to take up the ſulphuric acid with which the gas is generally more or leſs mixed, while the purified ſulphurous acid is abſorbed by the water in the ſecond and ſucceeding bottles. This liquid acid abſorbs oxygen from the air, and is gradually converted into ſulphuric acid. But if a little of it is confined in a glaſs tube, hermetically ſealed and expoſed to the common heat of a ſand bath for a few weeks, the inſide of the tube will be obſerved to be lined by degrees with minute cryſtals: after a time the depoſition of cryſtals will ceaſe: if then the end of the tube be broken off under mercury, this latter fluid will riſe in the tube, ſhewing that a portion of the air has diſappeared, and the reſidue, on examination, will be found to be wholly deprived of oxygen: the liquid which was pure ſulphurous acid, will be converted, for the moſt part, into ſulphuric, and the cryſtals are ſulphur.[d] Hence it appears, that by the long continuance of heat, the oxygen of the liquid ſulphurous acid quits one part of its baſe in order to form ſulphuric acid with the remainder.

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[b] Experim. methodized, vol. ii. p. 311.

[c] Ann. de Chim. vol. xxiv. p. 237.

Sulphurous acid combines, either directly or by compound affinity, with the different ſalifiable baſes, forming a genus of ſalts, which have obtained the name of *Sulphites*.

For an account of ſuch of the metallic ſulphites as are known, we refer the reader to the reſpective metals: there are, however, two or three general obſervations on the ſubject, for which the chemical world is indebted to Berthollet, which may not improperly be introduced here. Thoſe metals that have a ſtrong affinity, both for oxygen and ſulphur, ſuch as iron and tin, if digeſted with liquid ſulphurous acid, furniſh themſelves with the requiſite proportion of oxygen, by decompoſing not the water but the acid; hence there is no diſengagement of hydrogen gas, but one portion of the metal decompoſes part of the acid, and after being thus oxydized, combines with the remainder of the acid and a little ſulphur, while the reſt of the ſulphur produced by the decompoſed portion of acid, combines with the remainder of the metal: hence there is produced both a ſulphite and ſulphuret. Zinc, on the contrary, though in its affinity for oxygen it is equal to iron, yet being greatly inferior in its attraction for ſulphur, decompoſes the water of the ſulphurous acid rather than the acid itſelf; hence, during its ſolution, hydrogen gas is given out, and there is no appearance of any ſulphur.

Thoſe metals whoſe affinity for oxygen is but weak, as lead, mercury, and copper, are not acted on by ſulphurous acid.

Some remarkable circumſtances alſo occur, with regard to the action of metallic oxyds on this acid: ſome oxyds ſimply combine with the acid into a ſulphite; others, as the black oxyd of manganeſe, give out a portion of oxygen to the acid, converting it totally, or in part, to ſulphuric. Hence there is produced a ſulphat, either mixed or not with a ſulphite.

The only truſt-worthy analyſis of this acid which has yet been publiſhed, is Dr. Thomſon's;[e] from which it appears that 82 parts of ſulphuric acid, and 18 of ſulphur, conſtitute 100 of ſulphurous acid; according to which (if the analyſis of ſulphuric acid by Chenevix be aſſumed as the moſt authentic) this acid conſiſts of

68	Sulphur
32	Oxygen
100.	

The order of the affinities of ſulphurous acid, as far as it has been aſcertained, is the following: barytes, lime, potaſh, ſoda, magneſia, ammonia, and alumine. It is ſeparable in the form of gas from its earthy and alkaline baſes, by the ſulphuric, muriatic, phoſphoric, and tartaric acids.

Sulphurous acid, or to ſpeak more correctly the fumes of burning ſulphur, is employed to diſcharge the natural yellow tinge from white woollen cloth, and to reſtore ſilk that has grown yellow by long wearing, to its original whiteneſs. It is alſo uſed to check the fermentation of vinous liquors.

SULPHITE OF POTASH.[f]

The moſt convenient method of preparing this ſalt is to connect a retort, charged with ſulphuric acid and mercury, with a Woulfe's apparatus of two bottles, the former of them containing a little water, and the latter about two-thirds filled with a ſolution of cryſtallized carbonat of potaſh, in thrice its weight of water. The retort being heated, ſulphurous acid gas is produced, which paſſing through the water in the firſt bottle, is thereby purified from any contamination of ſulphuric acid, and then enters the alkaline ſolution in the next bottle, by which it is rapidly abſorbed, carbonic acid gas eſcaping in bubbles at the ſame time. When the effervescence has ceaſed, and the ſulphurous acid is no longer taken up by the liquor, the proceſs is finiſhed, and the liquor, as it cools, generally depoſits cryſtals, if the above proportions of alkali and water have been obſerved.

Sulphite of potaſh thus prepared, is a tranſparent ſalt, ſometimes colourleſs, but often with a ſlight yellowiſh tinge. It cryſtallizes either in the form of lengthened rhomboidal plates or divergent needles. To the taſte it is pungent and ſulphurous; its ſpecific gravity is = 1.58: it is readily ſoluble in its own weight of water at the common temperature, and in a much ſmaller quantity of boiling water. If this ſolution is expoſed to the air, it becomes covered in a ſhort time with a cryſtalline pellicle; when this falls to the bottom, it is ſucceeded by another, and ſo on till the whole is converted into ſulphat of potaſh. If oxygen gas is employed in the above experiment, inſtead of atmoſpheric air, the oxygenation of the ſalt takes place much more rapidly, with a very evident abſorption of the gas. By expoſure to a temperature of about 300° Fr. ſulphite of potaſh loſes about two per cent. which appears to be water. When heated in a retort, it firſt decrepitates, and is converted into an opake white powder, and on an increaſe of temperature loſes about 22 per cent. of which 15 are ſulphurous acid gas, 5 are ſulphur, and 2 water; the ſalt that remains behind is ſulphat of potaſh, with a ſlight exceſs of alkali. If, inſtead of being heated in a retort, it is rapidly ignited in a platina crucible, after the decrepitation has ceaſed, a blue flame makes its appearance, occaſioned by the combuſtion of the ſulphur, after which the ſalt is found to have loſt 22 per cent. as before. The component parts of this ſalt, according to an analyſis by Dr. Thomſon, are

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[d] Prieſtley,

[e] Nich. Journ. 8vo. vol. vi. p. 95.

[f] An de Chim. vol. xxiv. p. 254. Nich. Journ. vi. p. 94.

43.5	Sulphurous acid
54.5	Potaſh
2.0	Water
100.0	

This, as well as the other ſulphites, is moſt conveniently analyſed in the following manner: firſt aſſay the ſolution with ſulphite of barytes, to aſcertain whether any mixture of ſulphat is preſent, and having thus got rid of the ſulphuric acid, add nitrat of lead as long as any precipitate falls down. The ſulphite of lead thus obtained, conſiſts, according to Dr. Thomſon, of 23 per cent. ſulphurous acid, and 75 yellow oxyd of lead.

Nitric acid converts this ſalt into ſulphat of potaſh; oxymuriatic acid produces a ſimilar effect, but at the ſame time drives off a portion of ſulphurous acid, ſo that the reſulting ſulphat is mixed with a little muriat.

It is alſo converted into ſulphat by the oxyds of gold, ſilver, mercury, the red oxyd of lead, and the black oxyd of mangaueſe.

It is decompoſed, by compound affinity, by all the earthy and alkaline ſulphats, except ſulphat of barytes; by the nitrats, with the exception of nitrat of ammonia; by the muriats, with the exception of muriat of alumine; by the phoſphats of ſoda, ammonia, alumine, and glycine; by the fluats of ſoda, ammonia, barytes, ſtrontian, and magneſia; by carbonat of ſoda; and by all metallic ſalts except the carbonats. It has not been applied to any uſe.

Sulphite of Soda.

This ſalt is prepared from carbonat of ſoda, in the ſame manner as ſulphite of potaſh is from carbonated potaſh. It forms at firſt a confuſedly cryſtallized maſs, which by ſubſequent ſolution in hot water affords, on cooling, very regular diſtinct cryſtals, in the form of compreſſed tetrahedral priſms, with dihedral ſummits. Its ſpecific gravity is = 2.95. To the taſte it is cooling and ſulphurous. It is ſoluble in four times its weight of water, and in leſs than its own weight of boiling water. It effloreſces on expoſure to the air, and becomes covered with a white cruſt, but does not fall into powder as ſulphat of ſoda does; hence, although it is ſoon converted ſuperficially into ſulphat, yet the interior of the cryſtal remains for ſome time unaltered. When heated, it firſt melts in its water of cryſtallization, and on increaſing the temperature, undergoes changes preciſely analogous to thoſe already deſcribed in the preceding article. It is compoſed, according to Dr. Thomſon, of

31	Sulphurous acid
18	Soda
51	Water
100.	

It is decompoſed by the alkaline and earthy ſulphats, with the exception of the ſulphats of barytes and ſoda; by the earthy nitrats; by the ammoniacal and earthy muriats, phoſphats, and fluats; by the borat and carbonat of potaſh; and by moſt of the metallic ſalts. It has not yet been applied to any uſe.

Sulphite of Ammonia.

This ſalt is prepared in the manner deſcribed under ſulphite of potaſh, by ſaturating a ſolution of cauſtic ammonia with gaſſeous ſulphurous acid. It cryſtallizes either in hexahedral priſms, terminated by hexahedral pyramids, or in rhomboidal priſms, with obſcure trihedral ſummits. To the taſte it is cooling and pungent, with a ſulphurous flavour. It is ſoluble in its own weight of cold water, and in a ſmaller proportion of boiling water. By expoſure to the air it attracts moiſture, and is ſpeedily converted into ſulphat of ammonia; after which it becomes dry again. When heated, it ſlightly decrepitates, gives out a little water and ammonia, and then ſublimes in the ſtate of acidulous ſulphite. In its general properties it reſembles the other ſulphites, but combines with ſeveral of the ſalifiable baſes into triple ſalts.

It is decompoſable by the ſulphats of magneſia, alumine, and zircon; by the earthy nitrats and muriats; by the acidulous phoſphat of lime; and the phoſphats of alumine, glycine, and zircon; by the fluats of barytes, ſtrontian, and magneſia; the borats of potaſh, ſoda, barytes, ſtrontian and magneſia; and the carbonats of potaſh, ſoda, and barytes. It is not made any uſe of.

Sulphite of Barytes.

This ſalt may be prepared, in the manner already mentioned, with either pure barytes or the carbonat reduced to a fine powder; or it may be obtained by compound affinity from a mixture of an alkaline ſulphite with muriat of barytes. It is in the form of a white powder, inſoluble in water and taſteleſs. By long expoſure to the air, it is converted into ſulphat of barytes. When ſtrongly heated, ſulphur is diſengaged, and the reſidue becomes ſulphat. But this ſalt, though inſoluble in water, may without much difficulty, be diſſolved in liquid ſulphurous acid, and by ſlow evaporation, may be obtained in needle-form cryſtals, or truncated tetrahedrons. Theſe cryſtals are ſometimes tranſparent, but often opake; they are hard and nearly inſipid, but at length leave a ſulphurous flavour on the palate; they are rather ſparingly ſoluble in water; and the ſolution is employed with advantage to purify the ſulphites from any admixture of ſulphat. The cryſtallized ſulphite conſiſts, according to Fourcroy, of

59.	Barytes
39.	Sulphurous acid
2.	Water
100.	

It is decompoſed by the ſulphats; by the alkaline phoſphats; by the nitrat and muriat of ſtrontian, and by the alkaline carbonats. It is not made any other uſe of than that already mentioned.

Sulphite of Lime.

This ſalt is prepared either with pure or carbonated lime, in the manner above deſcribed. It is in the form of a white powder, but by digeſtion in liquid ſulphurous acid, it diſſolves, and by ſlow cooling cryſtallizes in minute hexahedral priſms, with hexahedral ſummits. To the taſte it is after ſome time ſlightly ſulphurous. It is ſoluble in 800 parts of water. By expoſure to heat the cryſtals fall into powder, and a little water comes over; at a red heat, a little ſulphur is diſengaged, and the reſidue is ſulphat of lime. By long expoſure to the air, it becomes ſomewhat effloreſcent, and, after a conſiderable time, is changed into ſulphat. Its component parts, according to Dr. Thomſon, are

48.	Sulphurous acid
47.	Lime
5.	Water
100.	

It is decompoſed by the alkaline and earthy phoſphats; by the fluats and carbonats of barytes, ſtrontian, and the alkalies; and by moſt of the metallic ſalts. It is made no uſe of.

Sulphite of Magnesia.

This ſalt is prepared with carbonated magneſia diffuſed in twice its weight of water, in the manner already deſcribed. It is in the form of powder, but by an additional portion of ſulphurous acid it readily diſſolves, and by gradual evaporation it is depoſited in the form of tranſparent depreſſed tetrahedral pyramids. To the taſte it is at firſt ſweetiſh and earthy, and afterwards ſulphurous. When expoſed to the air it becomes opake, and is very ſlowly converted into a ſulphat. It is ſoluble in 20 parts of water at the common temperature; boiling water takes up an additional portion, which it depoſits in cryſtals on cooling. It is very readily converted into ſulphat by expoſure to the air. When expoſed to a dry heat it ſoftens and aſſumes the conſiſtence of viſcid gum, and at length dries, having loſt 45 per cent. which is nearly pure water; at a higher heat the ſulphurous acid riſes unaltered, and the earth remains behind. From this mode of analyſis it appears, according to Fourcroy, to conſiſt of

39	Sulphurous acid
16	Magneſia
45	Water
100	

It is decompoſed by the alkaline and earthy-alkaline carbonats; by the ſulphats of alumine and zircon; by the earthy nitrats; by the phoſphats of the alkalies, and of lime, glycine, alumine, and zircon; and the alkaline borats. It is not applied to any uſe.

Ammoniaco-Magnesian Sulphite.

This ſalt is formed, according to Fourcroy, by mixing magneſia with ſulphite of ammonia, or ammonia with ſulphite of magneſia, or by adding together the two ſulphites. It occurs in the ſtate of ſmall tranſparent indeterminate cryſtals; it is leſs ſoluble in water than either of the two ſulphites ſeparately, of which it is compoſed. By expoſure to air it changes into the triple ſulphat of ammonia and magneſia. When heated it gives out firſt ſulphurous acid, then acidulous ſulphite of ammonia ſublimes, and pure magneſia remains behind. The proportion of its conſtituent parts has not been aſcertained. It is decompoſable by barytes, ſtrontian, lime, and the fixed alkalies. It is not made any uſe of.

Sulphite of Alumine.

This ſalt is formed from pure alumine, according to the proceſs already mentioned. It is in the ſtate of a white ſoft powder; to the taſte it is ſweetiſh, and then ſulphureous. It is inſoluble in water, but is taken up by an exceſs of acid. It is not cryſtallizable. By expoſure to the air it is gradually converted into ſulphat. When heated, ſulphurous acid is driven off and the earth remains behind, together with a little ſulphat. It is compoſed, according to Dr. Thomſon, of

32	Sulphurous acid
44	Alumine
24	Water
100	

It is not applied to any uſe.

SUMACH. *Rhus Coriaria*, Linn.

The ſumach is a ſhrub which grows naturally in Spain, Portugal, Syria, and many parts of the Levant, and is largely employed in dyeing.[a] Every part of the tree appears impregnated with aſtringent matter: the entire twigs and branches are the parts employed, which are dried, and ground in a mill into a coarſe brown or yellowiſh-green powder, which is the ſtate in which it is imported.

Sumach readily yields a yellowiſh green infuſion with warm water, which ſoon turns brown on expoſure to air. This infuſion gives a ſmall quantity of yellow lake with alum, and with the ſolutions of iron it forms an abundant black or dark brown precipitate, ſhewing the preſence of gallic acid. It is largely uſed in dyeing; by itſelf it gives a yellow-buff or fawn colour tending to green, which however is fugitive unleſs fixed by a mordant. If a ſalt of iron enters into the mordant, the black of the gallat of iron then produced mixes with the natural colour of the ſumach, and a vaſt variety of uſeful grey, drab, and ſlate colours are brought out. Sumach, like the gall-nut, alſo contains a very large quantity of *Tan*, and hence will give a copious precipitate with infuſion of glue or any other animal jelly; ſo that it has an additional uſe in the preparation of *leather*, the finer kinds of which (as mentioned under that article) are tanned by ſumach.

A good deal of ſulphat of lime is found in the infuſion of ſumach, by the barytic and oxalic teſts. The infuſion of this plant differs from that of the other aſtringent vegetables in giving a precipitate with the cauſtic alkalies, which is probably owing to the ſulphat of lime which it contains. (*See the article* Tannin.) Mr. Davy obtained 165 grs. of matter ſoluble in water from 480 grs. of Sicilian ſumach, of which he eſtimates 78 grs. to be tannin.

SWINESTONE. *Stinkſtein*, Wern. *Pierre puante*, Broch.

Its colour is dark ſmoke-grey paſſing into greyiſh black, yellowiſh grey or blackiſh brown. It occurs in maſs, and ſometimes diſſeminated. Its internal luſtre varies from dull to glimmering. Its fracture is fine grained ſplintery, or fine grained earthy; ſometimes it is imperfectly lamellar or ſlaty; the black variety is more or leſs conchoidal. Its fragments are either indeterminately angular, or ſlaty. It ſometimes contains very ſmall-grained diſtinct concretions. It is opake, ſometimes a little tranſlucent on the edges. It gives a greyiſh-white ſtreak, may be eaſily ſcratched with a knife; is brittle, and eaſily frangible; when rubbed it gives out a ſtrong fetid urinous odour (whence its name.)

It effervеſces ſtrongly with acids, and the gas thus liberated is carbonic acid mixed with a little ſulphuretted hydrogen. By calcination it becomes white, and is converted into quicklime.

It occurs in beds alternating or intermixed with ſtratified gypſum, or ſtratified limeſtone. It is found in England, Germany, France, and moſt other countries. The harder and more compact varieties being capable of a good poliſh are often employed in ornamental architecture for marble. It is alſo uſed as a material for building, and when burnt affords excellent quicklime. Its peculiar odour has been attributed by ſome to a mixture of bitumen, and hence it has been improperly confounded with bituminous limeſtone.

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[a] Berthol
let Art de la Teinture.

T

TALC. *Talk*, Wern. *Talc*, Broch.

Of this mineral there are the three following ſubſpecies.

Subſp. Earthy Talc. Talcite of Kirwan.

Its colour is greeniſh-white paſſing into reddiſh white, ſilver-white, pale apple-green, and bright grey. It occurs diſſeminated, ſuperficial, or in ſmall kidney-ſhaped maſſes. It has a gliſtering pearly luſtre, and is compoſed of ſlightly agglutinated ſcaly particles; it ſtains the fingers, and is very unctuous to the touch.

It is found at Sylva in Piedmont; near Freyberg in Saxony; and at Meronitz in Bohemia.

It has ſometimes been confounded with agaric mineral.

2. *Subſp.* Common Talc. Venetian Talc.

Its colours are greeniſh white, pale apple-green, ſilvery-white, leek-green, and reddiſh or yellowiſh white. It occurs in maſs, diſſeminated, and very rarely cryſtallized, in minute hexagonal tables confuſedly grouped together. It has a conſiderably ſhining pearly luſtre, paſſing into ſemi-metallic. Its fracture is curved and undulatingly lamellar; its fragments are in the form of plates or wedges. It occurs ſometimes in granular diſtinct concretions. It is tranſlucent and in thin plates tranſparent; is ſoft, ſectile, flexible but not elaſtic, unctuous to the touch. It is infuſible before the blowpipe without addition. According to an analyſis by Hoepfer it conſiſts of

50.	Silex
44.	Magneſia
6.	Alumine
100.	

It is rarely found except in primitive mountains particularly forming beds and veins in ſerpentine, accompanied by actynolite, ſteatite, &c. It abounds in the mountains of Tyrol and Salzburg, whence it was brought to market at Venice, and from this circumſtance received the name of Venetian talc. It is alſo found at Zöblitz in Saxony, in Sileſia, and other places.

It is employed as a baſis for coloured crayons, and for the fineſt rouge.

3. *Subſp.* Indurated Talc.

Its colour is greeniſh-white of different degrees of intenſity, alſo ſnow white, and yellowiſh white.

It occurs in maſs. It has a brightly ſhining luſtre, between pearly and greaſy, paſſing ſometimes into ſemi-metallic. Its fracture is curved, lamellar, paſſing into ſlaty, or coarſely radiated. Its fragments are uſually in the form of blunt edged plates. It is tranſlucent, and in thin pieces, ſemi-tranſparent; is very ſoft; ſectile; ſmooth and unctuous to the touch.

Its conſtituent parts, according to Hoepfer, are,

38.54	Magneſia
38.12	Silex
6.66	Alumine
0.41	Lime
15.02	Iron
98.75	

It forms beds in mountains of argillaceous and micaceous ſchiſtus, of gneiſs and the neweſt ſerpentine. It is accompanied by actynolite, calcareous ſpar, bitter ſpar, pyrites, and mica.

It appears to form an intermediate link between ſteatite and potſtone. French chalk (craie de Briançon) is by ſome mineralogiſts referred to this ſpecies.

It is found in the Alps, in Stiria, Auſtria and Hungary, and according to Jameſon in Breadalbane, and the Shetland Iſlands in Scotland.

TALCITE of Kirwan. See Talc *earthy*.

TAN or **TANNIN.**
TANNING, (*the Art of*) }

The general properties of tannin particularly as connected with the art of tanning, have been deſcribed pretty fully under the articles Leather and Gelatin; and the properties of the compound of tannin, gallic acid, and extract, with various earthy and other ſalts, which exiſts in the infuſion of aſtringent vegetables, have been given under the article Galls, to all of which we muſt refer the reader. It will be proper however in this place ſlightly to recapitulate the general properties of tannin, the methods by which chemiſts have endeavoured to obtain it pure, and thoſe by which its relative proportion to the other contents of aſtringent infuſions have been eſtimated. We ſhall alſo add an account of the late experiments by which Mr. Hatchett has produced a ſubſtance cloſely reſembling tannin.

The ſubſtance called tan or tannin, is diſtinguiſhed by its ſtrong aſtringent taſte, by a peculiar ſmell, by forming immediately with a ſolution of gelatin a whitiſh compound inſoluble in water and alcohol, and by uniting to animal ſkin (which is chiefly gelatine in a condenſed ſtate) immerſed in it, rendering it harder, leſs pervious to water, and no longer ſuſceptible of putrefaction. Theſe are the peculiar advantages procured by the art of tanning which has been deſcribed under the article *Leather*.

It is not certain whether we have ever procured pure tannin, (at leaſt the natural tannin) for all the parts of vegetables that contain it alſo give out on infuſion a quantity of extract, ſometimes mucilage, often gallic acid, beſides ſome ſaline ſubſtances, and as the chemical difference between ſome of theſe bodies appears but ſlight, and as all ſoluble vegetable matter poſſeſſes many properties in common, it is extremely difficult to obtain any one of them ſeparate.

Prouſt[a] who has made many reſearches on tannin, gives the following method of obtaining it from the decoction of galls.

Pour into the decoction a ſolution of muriat of tin, which will give a copious yellow precipitate. Separate this by filtration, and when well waſhed it will conſiſt (as he aſſerts) of all the tannin united to the oxyd of tin. To ſeparate theſe two, diffuſe the precipitate in water, and paſs a current of ſulphuretted hydrogen gas through the liquid. By degrees an inſoluble hydro-ſulphuret of tin will be precipitated, and the tannin, now ſeparated from the oxyd, will reſume its ſolubility and diſſolve in the fluid, giving it the acerb taſte, and peculiar ſmell of the decoction of galls after the exceſs of ſulphuretted hydrogen has been expelled by boiling. This ſolution lathers like ſoap water on agitation, and when concentrated by boiling it depoſits a brown powder on cooling, which is re-diſſolved by heat. When evaporated to dryneſs it leaves a dry, brown, friable, reſinous looking maſs like aloes, which does not deliqueſce, has an intenſely acerb taſte, rediſſolves in water and alcohol, and then gives an immediate precipitate with the ſolutions of gelatine, which is the moſt characteriſtic property of tannin.

The clear liquor that remains in the firſt part of this proceſs (that is after adding muriat of tin to the decoction of galls) contains gallic acid and muriat of tin.

Such was the original proceſs of this ingenious chemiſt,[b] but ſubſequent experiments convinced him that it was by no means ſo accurate as he had at firſt ſuppoſed, for the oxyd of tin has ſo ſtrong an affinity for other vegetable principles and particularly for extract, that this ſubſtance when preſent (which it generally is) accompanies the tannin in its precipitation with the oxyd of tin, and alſo in its ſubſequent ſolution in water after the oxyd has been removed by ſulphuretted hydrogen. A part alſo of the compound of tannin and oxyd of tin remains in ſolution inſtead of precipitating, ſo that this method of eſtimating the proportional quantity of tannin in any ſolution would be liable to a double error.

M. Prouſt alſo tried the effect of ſimply agitating the decoction of galls with the oxyd of tin (made by nitric acid and kept under water) which in a few days abſorbed all the tannin, but it equally took away the extract, leaving the ſupernatant liquor nearly clear. He alſo found that in this way the gallic acid, and part of the tannin were deſtroyed, that is, changed in ſuch a manner, that their reſpective diſtinguiſhing properties were loſt; ſo that on the whole not much advantage can be expected in theſe experiments, from the uſe of this powerful chemical agent.

Another method[c] propoſed by the ſame chemiſt of obtaining what he conceived to be pure tannin, was to pour into an infuſion of galls, a ſolution of potaſh thoroughly ſaturated with carbonic acid, ſuch as the cryſtallized carbonat of potaſh is, which produces a yellowiſh white curdy precipitate of the ſubſtance in queſtion. The liquors ſhould not be too dilute, nor the precipitate waſhed with too much water, as it is ſoluble in water, though ſparingly. This precipitate dries but ſlowly, but when ſpread over any ſmooth ſurface, in thin layers, and ſtoved, it becomes a brittle reſinous yellow maſs. This ſubſtance diſtilled *per ſe* gives a ſaline liquor with an ammoniacal ſmell, which blackens the ſolutions of iron, and alſo a little thick butyraceous oil, and leaves a bulky coal.[d]

Mr. Davy however, on repeating theſe experiments, found that this precipitate did not exhibit the properties of pure tannin, as it wants the peculiar aſtringent taſte, is but ſlightly ſoluble in cold water and alcohol, and the ſolution is not precipitated by gelatin till it is ſaturated with an acid. It alſo gives by incineration a conſiderable quantity of carbonat of potaſh, and ſome carbonat of lime. It alſo affords gallic acid by diſtillation.

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[a] An. Chim. tom. 25.

[b] Ibid. tom. 42.

[c] Ibid. tom. 35.

[d] Phil. Tranſ. for 1803.

From theſe and other facts it appears that this precipitate is not pure tannin, but is a very compounded ſubſtance containing tannin, gallic acid, alkali, and lime, and perhaps extract. The preſence of alkali is peculiarly indicated, by the circumſtance of its affording no precipitate with gelatine till ſaturated with an acid, which is preciſely the effect produced in the infuſion of galls by adding the cauſtic alkalies, as mentioned under the article *Galls*.

A compound of acid and tannin is produced on adding an acid to the infuſion of galls as has alſo been mentioned under that article. This precipitate is tenacious like pitch, and when it is waſhed with cold water, rediſſolved to ſaturation in boiling water, and a little carbonat of potaſh added to ſaturate the acid, another precipitate takes place, which now no longer contains any acid, and is ſuppoſed by Prouſt to be pure tannin. To obtain the whole of it, the remaining liquor ſhould be evaporated and then allowed to cool, and the precipitate waſhed with cold water.

This ſubſtance certainly contains the tannin more approaching to purity than in the former caſe, but as extract is alſo known to be precipitated by acids, it is probable that ſome of it is alſo contained in this caſe, and beſides it ſhews traces of gallic acid.

From all that has been done on this ſubject, it appears therefore that we cannot be certain that we have ever obtained pure tannin, free from all other admixture; and it is equally certain that none of theſe methods can extract the whole of this ſubſtance from vegetable infuſions; ſo that it is ſtill the beſt method, in experiments where the quantity of tan alone is required, to make uſe of the infuſion of animal gelatin, and eſtimate the quantity of tan from the weight of the compound of tan and gelatin thus produced.

With proper precautions, the gelatin only ſeparates the tannin from the vegetable infuſions; and this compound appears tolerably uniform in its nature, and in the proportion of its conſtituent parts, though we have not yet been able to ſeparate them without deſtroying the characteriſtic properties of each.

In applying the ſolution of gelatin to infuſions containing tannin, ſeveral circumſtances muſt be noted.[d] It appears, in the firſt place, that the mere dilution of the liquids influences the quantity of precipitate, this being the greateſt, in proportion as the ſolution of tannin is moſt concentrated.

This circumſtance introduces an unavoidable ſource of error, for though an uniform ſtandard of ſtrength may be adopted for the gelatin, by diſſolving a given quantity of iſinglaſs (which is nearly pure gelatin) in a known bulk of water, it is impoſſible to make an equally uniform ſolution of tannin from a compound vegetable ſubſtance.

The proportions of iſinglaſs and water employed by Mr Davy are 6 grains of the former to an ounce of liquid, which is nearly as ſtrong as can be made at a moderate temperature, without being inconveniently ſtiff and gelatinous. Care muſt be taken not to add an over proportion of gelatin to the vegetable infuſion, for when this happens, it appears that ſome of the compound is diſſolved in the mixture, as leſs of it is precipitated. Probably therefore gelatin unites with tannin in different proportions, and the compound is only inſoluble when the gelatin is in the inferior proportion. The precipitate ſhould always be dried at a tolerably uniform temperature ſomewhat higher than that of the atmoſphere. This precipitate is compoſed, according to Mr. Davy, on an average, of about 54 per cent. of gelatin, and 46 of tannin. There is much more tannin, however, in this compound, than in tanned leather, or ſkin ſaturated with tannin, though the conſtituent parts are nearly the ſame.

It remains to mention a very curious production of tannin by artificial means from ſubſtances which do not naturally contain a particle of it, lately diſcovered by Mr. Hatchett,[e] and partially noticed in this volume under the article *Reſin*.

The ingenious author was led to the diſcovery by purſuing his former experiments on *Bitumens* and *Bovey Coal*, and in particular on their habitudes with nitric acid. When a pure reſin is digeſted with this acid it is converted into an orange-coloured viſcid ſubſtance, which at firſt ſeparates, but by a further affuſion of acid is rendered ſoluble in water and alcohol. On the other hand when a bitumen is treated in this manner, the firſt effect of the acid is to ſeparate this orange-yellow ſubſtance, and at the ſame time to produce a *very dark brown ſolution*. Now as the bitumens were ſhewn by previous experiments to conſiſt of a reſin holding a portion of uncombined carbon, Mr. H. conceived that a ſeparation of theſe two ſubſtances was effected by the acid, and that the brown ſolution contained only the uncombined carbon diſſolved in nitric acid, whilſt the orange-coloured maſs was furniſhed by the reſin. This was confirmed by treating in the ſame way amber, aſphaltum, different ſpecies of pit-coal, and laſtly pure charcoal, all of which yielded the brown ſolution in abundance, particularly the charcoal, but only thoſe ſubſtances that contained bitumen depoſited any of the orange-coloured maſs. The charcoal therefore yielded none of this latter, but diſſolved compleatly in the acid, making a dark reddiſh-brown liquid. This liquid was ſlowly evaporated to dryneſs, and left a brown gloſſy ſubſtance, with a reſinous fracture, the properties of which are the following:

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[e] Davy.

[f] Phil. Tranſ. for 1805 & 6.

1. It is ſpeedily diſſolved by cold water and by alcohol.
2. Its taſte is highly aſtringent.
3. Expoſed to heat it ſmokes but little, ſwells much, and affords a bulky coal.
4. The watery ſolution reddens litmus paper.
5. The ſame ſolution copiouſly decompoſes the metallic ſalts, eſpecially muriat of tin, acetite of lead, and red ſulphat of iron, forming brown or chocolate-coloured precipitates.
6. It precipitates gold from its ſolution, in the metallic ſtate.
7. It alſo precipitates the earthy ſalts.
8. The fixed alkalies at firſt only deepen the colour of the ſolution, but after a time render it turbid.
9. Glue or iſinglaſs diſſolved in water and added to the above ſolution forms an immediate precipitate more or leſs brown according to the degree of concentration, which is inſoluble in cold or boiling water, and appears cloſely to reſemble the precipitate formed by adding gelatin to the infuſion of galls or other vegetable aſtringents.

From theſe facts it appears that whenever carbon, either as ſimple charcoal or in natural mixture with reſins in the form of bitumen or coal, is digeſted in nitric acid, it is ſpeedily diſſolved therein, and is then converted into a ſubſtance cloſely reſembling the natural *Tannin*, from which moſt of the exceſs of acid may be ſeparated by cautious drying, and re-ſolution in water.

This artificial tannin is probably purer than tannin procured in any way from vegetable infuſions, being entirely free from gallic acid, though ſomething reſembling extract is produced along with the tannin.

Further experiments confirm the ſtrong reſemblance of the artificial with the natural tannin. When ſulphuric acid is added to the artificial ſolution it becomes turbid, and a copious brown precipitate ſubſides, which is ſoluble in boiling water, and then precipitates gelatin. When carbonat of potaſh is added, the colour is deepened, and a brown flocculent ſubſtance ſubſides.

Pure ammonia diſſolves the artificial tan, and this ſolution gives no precipitate with gelatin till neutralized by an acid. In all theſe circumſtances it agrees cloſely with the natural tannin.

When a ſolution of artificial tannin, made by pure charcoal and nitric acid, is precipitated as much as poſſible by gelatin, the ſupernatant liquor yields by ſlow evaporation to dryneſs, a light brittle cinnamon-brown ſubſtance, with a ſtrong odour reſembling that of oak-bark, ſoluble in water, ſcarcely acted on by gelatin, but precipitating the ſolutions of iron, tin, and lead, and which in ſome degree reſembles extract; ſo that this latter ſubſtance appears alſo to be an artificial as well as a natural production.

The chief, if not the only material, difference which has hitherto been found between the natural and the artificial tannin is, that the former has its diſtinguiſhing properties, particularly that of precipitating gelatin, entirely deſtroyed by digeſtion with nitric acid; whereas the artificial kind is made by means of this acid, and reſiſts all further change by it, in any temperature, at leaſt for a conſiderable length of time.

It has been mentioned that when nitric acid is digeſted with any ſpecies of reſin, if the latter contains no uncombined carbon, it is reſolved into an orange-coloured viſcid maſs, of itſelf inſoluble in the liquid, but which may be diſſolved by a further affuſion of acid. In this ſtate it gives no precipitate with gelatin, and therefore contains no tannin fully formed; but Mr. Hatchett found that on repeatedly abſtracting the acid to dryneſs, the reſidue became ſoluble in water, forming a clear yellow liquid, in which the preſence of tannin was then detected by the ſolution of iſinglaſs. Any kind of reſin will yield tannin in this manner, as will ſome of the gum reſins that have been examined. This therefore is a ſecond mode of forming the artificial tannin. The ſimple nitrous ſolution of indigo alſo gives a portion of tannin, together with an intenſely bitter cryſtallizable ſubſtance.

There is ſtill another method of producing it, which is by means of ſulphuric acid. When a reſin is immerſed in this acid it is ſpeedily diſſolved, forming a brown-red ſolution, which by continuing the digeſtion turns to black. Heat is not neceſſary to effect the ſolution, but haſtens it. After a time much ſulphureous and carbonic acids are given out, and if after this the ſolution is copiouſly diluted with cold water a black maſs ſubſides, which is partially ſoluble in alcohol, and this alcoholic ſolution is totally decompoſed by gelatin, and therefore contains an artificial tannin. It is not neceſſary however to make a compleat ſolution of the reſin in this acid, for if it is long digeſted with a ſmaller quantity of the acid, the ſame gaſſes are given out, and the reſidue becomes converted into a black charred maſs from which tannin may be extracted by alcohol. Not only the reſins, but oil, wax, camphor, and many other inflammable ſubſtances will yield tannin by digeſtion with ſulphuric acid, but ſome with much more eaſe than others. The tannin appears to be the ſame in all, and there appears to be a certain period of the proceſs when the production of the tannin has arrived at its greateſt quantity, after which a gradual diminution of it takes place, and it finally diſappears, and the ſubſtance becomes mere coal.

There is therefore this difference between the action of the nitric and ſulphuric acid upon reſins and other inflammable bodies, which is, that the production of tannin by the former acid is an ultimate effect, beyond which, no further change takes place by a continuation of the proceſs; whereas with the ſulphuric, it is only an intermediate product, which is loſt on further digeſtion.

The tannin produced by ſulphuric acid appears alſo to be much weaker in energy than that formed by the nitric.

From all theſe original and truly valuable experiments therefore, it appears that artificial tannin may be made in the following ways:

1. By ſimply diſſolving in nitric acid, either pure charcoal, vegetable or animal, or vegetable compounds that contain naturally any quantity of uncombined charcoal, or in which charcoal has been produced by previous expoſure to heat, or by ſulphuric acid. In theſe the quantity of tannin is directly proportioned to that of the charcoal ſolely.

2. By repeatedly abſtracting nitric acid off moſt of the reſins, and ſome other vegetable inflammables, which is totally independent of any uncombined charcoal that they may contain.

3. By long digeſtion of reſins, oils, and ſome other ſubſtances with ſulphuric acid, ſtopping the proceſs before the ultimate effect of the acid is produced, and extracting the tannin from the half-charred maſs by alcohol.

Further experiments are required to aſcertain what difference there may be between theſe varieties of artificial tannin, and between theſe and natural tannin. With reſpect to the latter queſtion, one ſtriking difference appears, which is, that the natural ſpecies is totally decompoſed by nitric acid, whereas the artificial is both produced by it, and is not eaſily, if at all, alterable by any continuance of its action.

TANTALIUM.

Of this metallic ſubſtance, newly diſcovered by Ekeberg, the following are all the particulars that have hitherto been publiſhed.

§. 1. *Ores of Tantalium.*

Sp. 1. Tantalite.

The external colour of this mineral is iron-black, that of a recent fracture is ſomewhat lighter with a bluiſh tinge; when pulverized it is a blackiſh grey. It occurs imbedded in detached cryſtals of the ſize of a hazel-nut; the form of the cryſtals is an ill defined octohedron. Its fracture is compact, and preſents a faint metallic luſtre. It gives ſparks when ſtruck againſt the ſteel. Sp. gr. 7.95.

Its component parts are tantalium, iron, and mangameſe.

It occurs near Brockaern in the pariſh of Rimito in the government of Abo in Finland, in a vein of quartz and mica, traverſing a rock of granite.

Sp. 2. Yttrotantalite.

The colour of this mineral when recently broken is iron black. It occurs in nodules not larger than a hazel-nut. Its fracture is compact granular with a metallic luſtre. It may be ſcratched, though with difficulty, by a knife. The colour of its ſtreak is greyiſh. Sp. gr. about 5.1.

It is compoſed of tantalium and yttria.

It occurs at Ytterby in Sweden, in a granite rock, accompanied by gadolinite.

§. 2. *Phyſical and Chemical Properties.*

Tantalium is obtained from its ores by treating them alternately with cauſtic fixed alkali, and muriatic or nitro-muriatic acid. The alkaline ſolution being ſuperſaturated with an acid lets fall a white powder which is oxyd of tantalium, the ſpecific gravity of which after ignition is =6.5. This oxyd if ſtrongly heated

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[*] Journ. de Phyſ. vol. lv. p. 283.

in a crucible lined with charcoal is reduced into a button of moderate hardneſs with a ſlight metallic luſtre ſuperficially, but internally blackiſh and quite dull. The only action which the acids have on this regulus, is to reduce it to the ſtate of white oxyd. Borax and phoſphat of ſoda, when aſſiſted by the blowpipe, diſſolve this oxyd, but receive from it no tinge of colour.

TAR. See TURPENTINE.

TAR, *Mineral*. See BITUMEN.

TARRAS. See CEMENTS, *Calcareous*.

TARTAR. *Weinſtein*. Germ.

The ſubſtance called *Tartar*, is a hard, brittle, brown-red maſs, interſperſed with imperfectly cryſtallized particles, which is depoſited on the ſides of wine-casks, during, and after fermentation of the grape-juice, in the form of a thick ſolid cruſt. In this ſtate it is alſo called *Crude* or *Rough Tartar* or *Argol*, to diſtinguiſh it from that which is purified in the way that will be preſently mentioned.

Tartar is not furniſhed in equal quantity from all wines, but the more coloured and ſtronger-bodied wines yield the moſt. Tartar has a vinous and ſlightly acid taſte. It conſiſts of a large quantity of extractive matter, ſcarcely ſoluble in water, to which it owes its colour, and of a ſalt, quite white when pure, compoſed of acid of tartar united to a ſmall portion of potaſh, leſs than is required for the ſaturation of the acid, but which in this proportion forms a diſtinct cryſtallizable ſalt of conſiderable importance in ſeveral arts and manufactures.

This ſalt when pure is called *Purified Tartar*, *Cream of Tartar*, *Cryſtals of Tartar*, or with more preciſion, *Acidulous Tartrite of Potaſh*, or *Super-Tartrite of Potaſh*. It is alſo called ſimply *Tartar*, but it is better to confine the term Tartar to the entire unpurified maſs. Tartar is not entirely a product of fermentation, for it is contained in the *Muſt*, or grape-juice, and aſſiſts in the proceſs of fermentation and the production of alcohol. The ſame ſalt in different combinations, has alſo been found native in ſome other vegetable juices.

Crude tartar is uſed pretty largely as a flux in the aſſaying of ores. As it contains both alkali and carbonaceous matter, it acts both in aſſiſting the fuſion of refractory ores, and in reducing metallic ſalts and oxyds. When heated *per ſe* to redneſs in cloſe veſſels, the extractive matter and the tartareous acid both become charred, and a black alkaline carbonaceous maſs is the reſult. In open veſſels the charcoal burns off totally, and at laſt nothing but pure white carbonat of potaſh remains.

But the greater part of the tartar is refined to extract the pure ſalt, which is performed largely in the South of France, near Montpellier, and alſo at Venice, and in two different methods.

The Venetian is the following:[a] The crude tartar is firſt dried in an iron boiler, with a very gentle heat and frequent ſtirring, that the acid may not be burnt, and is then pounded in iron mortars. The ground tartar is then diſtributed into wooden tubs, and boiling water poured upon it, which diſſolves the ſalt, and leaves a ſediment which is thrown away. The clear ſolution is left three days at reſt, during which time it depoſits browniſh cryſtals of tartar. The mother liquor from this operation is reſerved, and is uſed hot in the ſubſequent proceſs in the firſt lixiviation of the tartar. The browniſh cryſtals of tartar are then put into a copper boiler, with the mother-liquor of former proceſſes, and ſlowly brought to boil, by which a ſaturated ſolution of a deep yellow wine colour is produced. This is clarified in the following way: a workman ſtands by the ſide of the copper with a baſket of eggs, and a bucket full of finely ſifted wood aſhes. He begins with breaking one of the eggs, and putting the white of it only into a bowl; he beats this up with ſome of the boiling liquor, and then pours the whole into the boiler: he then inſtantly throws in a ladle-full of the wood-aſhes, and ſtirs up the liquor from the bottom. A briſk effervescence takes place, and the ſurface is covered with a red ſcum, which is carefully taken off with a perforated ſkimming-diſh and put aſide: a ſecond portion of aſhes is then added, and the effervеſcence and ſcum are renewed and treated as before. The whole of this operation is repeated fourteen or fifteen times, after which the liquor becomes quite clear and colourleſs. The fire is then withdrawn, and the liquor ſuffered to remain perfectly at reſt for three days. On the fourth, a dirty white ſaline cruſt is removed from the ſurface, and two-thirds of the liquor laded out: the cryſtals on the ſides are then collected by a ladle and waſhed in the remaining liquor; they are thus obtained perfectly clean, and require no further preparation than drying on a wicker frame. The cryſtals from the bottom are ſtill ſomewhat coloured, and are either ſold as an inferior ſort, or are refined again with freſh portions of the crude tartar. The liquor that remains in the boiler after the depoſition of the cryſtals is a cold ſaturated ſolution of tartar, and is employed in the firſt lixiviation of the rough tartar.

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[a] Deſmaret, in Journ. Phyſ. tom. 1, p. 67.

Tartar is refined near Montpellier in the following manner, according to the deſcription given by M. Fizes,[b] which has been found ſo convenient and efficacious that little if any change has been made in it for a century.[c]

The apparatus required for this purpoſe is 1ſt, a large copper boiler; 2d, a ſtone ciſtern, larger than the boiler; 3d, a number of glazed earthen pots (generally 27) which, together, hold ſomewhat more than the boiler; 4th, ſome ſtrainers of coarſe cloth ſtretched on wooden frames; 5th, four ſmaller copper boilers which, together, hold as much as the larger boiler, and are uſed in the refining part of the proceſs; and 6th, a mill to grind the tartar.

The large copper is firſt filled with two-thirds of mother liquor, remaining from the previous operations, and one-third of ſpring water, a quantity of rough tartar is then thrown in, and when the liquor is ſaturated and boiling it is ſtrained into the earthen pots. In about half an hour the liquor in theſe pots though ſtill very hot, begins to depoſit cryſtals on the ſurface and ſides of the pot, during which time more liquor and tartar are thrown into the large copper as at firſt.

The liquor in the pots is then emptied into the ſtone ciſtern, leaving the cryſtallized cruſt of tartar behind; and when the ſecond boiling is ſaturated, the pots are again filled as before, and the large copper again charged with the clear liquor from the ciſtern, and freſh tartar. By thus five times alternately preparing a hot ſaturated ſolution, and allowing it partially to depoſit its tartar in the pots, the latter become lined to a conſiderable thickneſs with a cruſt of reddiſh-white tartar, much purer than at firſt, and which obviouſly conſiſts of an irregular cryſtallized ſaline maſs, and when waſhed with cold water is fit for the ſecond, or proper refining proceſs. For this purpoſe the four ſmall boilers are filled with water, in which a ſmall quantity of clay is diffuſed, which renders it milky, rejecting the ſtony and larger particles of earth. The half-purified tartar is then added in ſuch proportion that the water when boiling ſhall be ſufficient to diſſolve all the ſoluble part, and the ebullition is continued for a quarter of an hour; the fire is then withdrawn, and the liquor allowed to remain at reſt till the next day. It is then found covered on the ſurface with a white hard ſaline cruſt, and a ſimilar cruſt, but more diſtinctly cryſtallized, has concreted on the ſides and bottom of the boiler. They are both very pure tartar, the cruſt on the ſurface, which is an amorphous maſs, is called *Cream of tartar*, and the other, *Cryſtals of tartar*, but they are indiſcriminately mixed.

The cruſt is then broken down and falls to the bottom, and the liquor, which is a clear pale red, is poured off gently into the ſtone ciſtern, till it begins to run white owing to the clay at bottom, which latter portion paſſes into a ſeparate veſſel. The whole maſs of ſolid tartar left in the boiler is then waſhed with cold water, till all the foulneſs (which is merely ſuperficial) is got out, and the water comes away quite clear, after which the purified tartar is taken out and dried on ſtoves or in the ſun, and is perfectly pure and white. The ordinary rough tartar yields about three-fifths of its weight of the white pure ſalt. All the residuary liquors are employed in ſubſequent operations in the way already mentioned.

The above two proceſſes of purifying tartar are conſiderably ſimple. Tartar conſiſts of the pure ſuper-tartrite of potaſh, or cream of tartar, united with a large quantity of extractive and colouring matter. Of theſe, the pure ſalt is entirely ſoluble in water, and much more ſo in hot than cold water, but it requires a very large proportion of water for ſolution; for even at a boiling temperature one ounce of the ſaturated ſolution holds no more than 16 grs. or $\frac{1}{30}$ of its weight of the ſalt, and on cooling only three or four grains are retained in ſolution. Hence the neceſſity of uſing a very large bulk of fluid in the proceſſes of ſolution and cryſtallization, and the advantage of employing the mother liquors or cold ſaturated ſolutions of former proceſſes. In each of theſe methods the tartar is firſt conſiderably purified by ſimple ſolution, filtration, and cryſtallization, but the ſubſequent part of the proceſs differs materially. In the Venetian method the white of egg is doubtleſs a very excellent, though ſomewhat more expenſive, ſubſtance for clarification; but the uſe of the wood-aſh is not very obvious, and would ſeem to be ſo far injurious as its alkali muſt neutralize a portion of the tartareous acid, and diminiſh the quantity of purified tartar by converting a portion of it to tartrite of potaſh, or that combination of this acid and potaſh in which the acid and alkali are in mutual ſaturation, and which being very ſoluble would remain in ſolution. Whether, as has been ſtated by ſome, the alkali of the aſhes would render the whole maſs of purified tartar leſs acidulous may be ſomewhat doubted, for the ſuper-tartrite of potaſh appears in all experiments to be a pretty uniform ſalt; and its little ſolubility, and the readineſs with which it ſeparates from its hot ſaturated ſolution, contribute to preſerve its compoſition unvaried in any mixture where it is produced at all.

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[b] Mem. de l'Acad. for 1725.

[c] Chaptal.

In the Montpellier mode of purification the earth uſed appears to be a tolerably pure clay, which readily diffuſes itſelf in water, and probably any other white clay would anſwer as well. The effect of the clay is to abſorb to itſelf the mucilaginous and coloured extract, and to carry it down in the form of an inſoluble ſediment; and when this operation is properly performed it appears on the whole to be ſuperior to the Venetian mode. The clay however ſhould be free from any admixture of chalk, and ſhould not effervesce with acids, for the chalk would readily neutralize that exceſs of acid which is eſſential to the compoſition of cream of tartar, as is ſeen in the proceſs where it is intentionally added to procure the tartareous acid, and will be deſcribed under that article.

Cream of tartar is a very valuable ſalt. It is chiefly uſed in dyeing, eſpecially in giving the ſcarlet and other modifications of the cochineal colours as deſcribed under the article *Dyeing*. It is alſo frequently combined with alum, as a mordant in fixing colours. An agreeable and very cheap acidulous drink is made by diſſolving this ſalt in water. The other chemical properties of this ſalt will be mentioned under the articles TARTRITES and TARTAREOUS ACID.

TARTAR EMETIC. See ANTIMONY.

TARTAR *Regenerated*. See ACETITE *of Potaſh*.

TARTAR. *Salt of*. A very pure *Carbonat of Potaſh* is made by calcining cream of tartar either *per ſe* or with nitre, whence the term Salt of tartar has long been, and ſtill is, very commonly applied to the pureſt ſub-carbonat of potaſh in whatever way obtained, and ſome of the ſalts with this alkali have had the name of tartar, as the following:

TARTAR *Vitriolated*. See SULPHAT *of Potaſh*.

TARTAR *Soluble*. See TARTRITE *of Potaſh*.

TARTAREOUS ACID.

It was Scheele, whoſe admirable ingenuity firſt deviſed the method of ſeparating from cream of tartar the pure tartareous acid, and obtaining it in a ſolid cryſtallized form.

His proceſs, with ſlight variation, is the following, which very cloſely reſembles the method uſed by this chemiſt to obtain the *Citric* acid: diſſolve any given quantity of cream of tartar in boiling water, and whilſt boiling add gradually ſome clean powdered chalk. A copious efferveſcence will ariſe, and the addition of chalk muſt be continued till this ceaſes, when the mixture may be ſet by to cool. It then contains a white denſe ſediment, which conſiſts of the lime of the chalk, united with the exceſs only of the acid of the cream of tartar; and the ſupernatant liquor is therefore a ſolution of the cream of tartar deprived of its exceſs of acid, or neutral *tartrite of potaſh*, or *ſoluble tartar* as it is alſo called, and which may be obtained cryſtallized by ſubſequent evaporation. Waſh the precipitated tartrite of lime repeatedly with cold water, then put it into a glaſs veſſel, and add to it a diluted ſulphuric acid, compoſed of as much concentrated acid as is equal to the weight of chalk employed in ſaturating the cream of tartar, mixed with four or five times its weight of water.

The ſulphuric acid having a ſtronger affinity for the lime than the tartareous acid has, totally decompoſes the tartrite of lime during a digeſtion of two or three days (or in a ſhorter time if aſſiſted by a gentle heat) and the white ſediment, though it does not alter its appearance, is changed to ſulphat of lime, whilſt the ſupernatant liquor contains naked acid of tartar. Then pour off the clear liquor, waſh the ſulphat of lime to extract all the adhering acid, and add the waſhings to the former liquor, and evaporate the whole (at firſt with a boiling heat, and as it concentrates, with a much gentler warmth) till it is of a thick ſyrupy conſiſtence, and then ſet it by for ſome hours that all the ſelenite which it may hold in ſolution may be depoſited. Then again dilute the mixture with cold water ſufficient to rediſſolve every thing but the ſelenite, and ſlowly evaporate the ſolution to a ſyrupy conſiſtence, and after ſome hours it will depoſit the pure tartareous acid in cryſtals, which are generally pretty large irregular hexahedrons. Cream of tartar decompoſed in this way by chalk (and therefore only partially) will yield about a third of its weight of the cryſtallized acid. This quantity however muſt not be taken as the proportion of the acid in cream of tartar, for much of the weight of the cryſtallized acid is water of cryſtallization, whereas the cream of tartar contains very little water.

Some nicety of management is required to obtain the utmoſt quantity of the acid and with the leaſt repetition of the alternate ſolutions and evaporations. M. Lowitz[d] finds that it is better to uſe a ſlight exceſs of ſulphuric acid in the decompoſition of the tartrite of lime to enſure the total ſeparation of the tartareous acid; for if too little ſulphuric acid were added, the mixture would conſiſt of tartareous acid, of ſulphat of lime, and of ſome undecompoſed tartrite of lime, which latter is readily ſoluble in an exceſs of its own acid, ſo that the clear liquor would not be pure tartareous acid, but a very acid ſolution of tartrite of lime, from which the pure acid would cryſtallize with difficulty. On the other hand, if there was any conſiderable exceſs of ſulphuric acid it would produce equal inconvenience, both by diſſolving ſome of the ſulphat of lime, and alſo, when the acid liquor was much concentrated, by partially decompoſing and colouring the tartareous acid and leſſening the product.

To aſcertain whether the ſulphuric acid has been added in due proportion, take out a little of the clear liquor remaining after the tartrite of lime has been duly digeſted with the ſulphuric acid, and having diluted it, drop in ſome ſolution of acetited lead as long as any precipitate falls down, which will therefore conſiſt either entirely of tartrite of lead, or of a mixture of this ſalt with ſulphat of lead, according as there is or is not any exceſs of ſulphuric acid in the liquor. Then add ſome pure and moderately ſtrong nitric acid, and, if the precipitate conſiſts merely of tartrite of lead, it will be rediſſolved totally and immediately, and the ſolution will remain clear for ſome hours. If the precipitate contains much ſulphat of lead mixed with the tartrite it will not be wholly rediſſolved: but if only a ſmall quantity of ſulphat of lead be mixed with the tartrite it will firſt be totally rediſſolved, and in a few minutes after will become ſomewhat turbid. This latter is the exact point to be deſired, as it indicates a ſlight exceſs of ſulphuric acid, and the liquor may be brought to this ſtate by adding either more ſulphuric acid, or ſome reſerved tartrite of lime, according to circumſtances.

In the above mentioned mode of obtaining tartareous acid, chalk, or carbonat of lime, is uſed to decompoſe the cream of tartar, which it does merely by engaging the exceſs of acid and leaving the remainder of the ſalt in the ſtate of tartrite of potaſh. But if quick-lime be ſubſtituted to the chalk, the whole of the cream of tartar is decompoſed, a much larger quantity of tartrite of lime, and conſequently of tartareous acid, is obtained, and the ſupernatant liquor is a ſolution of cauſtic potaſh. It has been found however by Vauquelin, that the potaſh retains a ſmall quantity of tartrite of lime in ſolution, ſo that when the alkaline liquor is evaporated nearly to dryneſs it gelatinizes by cooling, owing to the ſeparation of this calcareous ſalt. It may be decompoſed by carbonat of potaſh or ſoda, which produces carbonat of lime and tartrite of the alkali employed: or the tartareous acid may be deſtroyed by calcination, and the lime, carbonated in the proceſs, will remain.

In uſing lime to decompoſe cream of tartar, the quantity to be added is not ſo readily aſcertained as with chalk, where the ceſſation of the efferveſcence is the ſign of the ſaturation of the acid. Where the lime is well burnt and of uniform purity, a little experience will guide the operator with ſufficient certainty. Calculating from the obſerved proportions of acid in the tartar, and of chalk required in the firſt-mentioned proceſs, and of pure lime in chalk, we may eſtimate that all the acid in 100 parts of cream of tartar (which Thenard[e] reckons at 57 per cent.) will require full 42 parts of pure lime for its ſaturation, and ſomewhat more lime ſhould perhaps be added to enſure the complete decompoſition of the tartar. The lime ſhould be previouſly ſlacked and mixed with ſufficient water to bring it to the conſiſtence of paſte.

Lowitz has propoſed another method which is perhaps preferable in every reſpect, except that it is ſomewhat more expenſive, and that no cauſtic alkali is obtained. It conſiſts firſt in decompoſing the cream of tartar by chalk in the uſual way, added as long as any efferveſcence takes place; and then pouring into the filtered ſupernatant liquor muriat of lime as long as any precipitate falls down. By this means the tartrite of potaſh in the liquor is totally decompoſed, muriat of potaſh remains in ſolution, and the precipitated tartrite of lime is added to that produced by the chalk; and both are afterwards decompoſed by ſulphuric acid in the uſual way. The ſame chemiſt alſo adviſes to add to the ſolution of tartareous acid in the laſt part of the proceſs a quantity of *Charcoal* powder, the depurating power of which has been mentioned under that article. This, however, is certainly not eſſential to the obtaining a perfectly fine colourleſs cryſtallized acid, and, we believe, is ſeldom if ever uſed.

Tartareous acid has a ſtrong and ſimply acid taſte, and is ſoluble in five or ſix parts of cold water, and in much leſs when boiling. The cryſtals are permanent in the air.

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[d] An. Chim. Tom. 34.

[e] An. Chim. Tom. 41. p. 51.

When heated *per ſe* in a retort with a receiver this acid melts, boils up, and exhales a ſour pungent vapour, which condenſes in the receiver into a red acid empyreumatic liquor, equal to about a quarter of the weight of the tartareous acid.

This liquor has a pungent acid and empyreumatic taſte, ſtrongly reddens litmus, and efferveſces with the alkaline carbonats. It is called the Pyrotartareous acid, which has not been much examined. The other products from the diſtillation of tartareous acid, are a large quantity of carburetted hydrogen and carbonic acid gas, and a ſoft ſpongy coal is left in the retort, which, heated in the open air, burns with ſcarcely any reſidue.

The tartareous acid, beſides being found native in ſome vegetable juices, and in the depoſit from wine during and after fermentation, is alſo produced by the action of nitric acid on alcohol. A further digeſtion of tartareous with nitric acid converts the former into oxalic acid, and a ſtill further digeſtion changes the whole of the vegetable acid into vinegar. Theſe curious experiments which were at firſt noticed by Scheele, have been more fully examined by Hermbſtaedt and other chemiſts, and are detailed under the article *Acetous* acid (p. 4.)

The compounds of the tartareous acid with the alkaline and earthy baſes, will be mentioned in the following article.

This acid is compoſed, according to Fourcroy[f] and Vauquelin, of 70.5 of oxygen, 19 of carbon, and 10.5 of hydrogen, and differs from the oxalic acid in containing more carbon and leſs oxygen. The order of affinity of this acid for the ſeveral baſes is (according to Thenard) lime, barytes, ſtrontian, potaſh, ſoda, ammonia, magneſia, and alumine.

TARTRITES.

The diſtinct combinations of the tartareous acid with the ſeveral baſes, are particularly numerous, as with ſome it forms two ſalts, differing in the proportions of acid and baſe, and as it is peculiarly liable to form triple ſalts in which two baſes are united with their reſpective portion of acid into one uniform compound.

All the ſoluble alkaline and earthy tartrites are decompoſed by the ſalts of lead, and the acid of all is deſtroyed by calcination, leaving the baſe in the ſtate of carbonat.

Super-tartrite of Potash. *Cream of Tartar. Tartareous Acidulum.*

The origin and manufacture of this ſalt has been mentioned under the article *Tartar*. It is compoſed of potaſh and tartareous acid in exceſs, and hence has an acid taſte and reddens blue vegetable colours. It is ſoluble with great difficulty, requiring about 30 parts of boiling water, and full 120 parts of cold water, and hence a hot ſaturated ſolution begins to depoſit cryſtals almoſt immediately after it begins to cool.

The affinity between the tartareous acid and that proportion of potaſh which conſtitutes the ſuper-tartrite, is ſo great that the acid of tartar will decompoſe, partially or totally, all the neutral ſalts of potaſh, even the ſulphat. But on the other hand, the affinity between the ſuper-tartrite and that additional quantity of potaſh which is neceſſary for complete ſaturation of this acid, (or which conſtitutes the tartrite of potaſh,) is much weaker than that of moſt other acids for potaſh, and hence ariſes a great number of decompoſitions when tartareous acid, potaſh, and any other acid are mixed in different ways. Thus if a ſolution of tartareous acid is poured into a ſolution of ſulphat of potaſh, rather concentrated, in a few ſeconds the mixture becomes turbid, and ſoon a quantity of a white granular powder falls to the bottom, which is cream of tartar, and may be diſtinguiſhed as ſuch (when rinced with cold water) by feeling hard and granular in the mouth, with a ſlightly acidulous taſte, being much more ſoluble in boiling than in cold water, and when heated by the blow-pipe, blackening, ſwelling up, and finally being reduced to a globule of pure carbonat of potaſh. The ſupernatant liquor conſiſts of the remainder of the potaſh of the ſalt, united with the whole of the ſulphuric acid, and no further addition of tartareous acid will complete the decompoſition. Two acidulous ſalts therefore are produced in this caſe, the ſuper-tartrite and the ſuper-ſulphat of potaſh, of which the former is moſtly precipitated, and the latter remains in ſolution. On the other hand, a production of cream of tartar takes place when dilute ſulphuric or any other acid is added to tartrite of potaſh. The acid added takes away from the tartrite only that quantity of potaſh which makes the difference between the tartrite and the ſuper-tartrite, and the latter is precipitated, and is not further acted on by any exceſs of the ſulphuric acid. This property of the tartareous acid, of decompoſing the neutral ſalts with the baſis of potaſh, is very uſeful in analyſis, as it diſtinguiſhes them at once from the correſponding ſalts of ſoda and ammonia, which are not decompoſed in the ſame way.

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[f] Syſteme, &c.

By ſaturating the exceſs of acid in cream of tartar with the ſeveral baſes (potaſh excepted) various compound or triple ſalts are produced, which will be mentioned preſently.

To obviate the inconvenience ſometimes produced by the very ſparing ſolubility of cream of tartar, Lemery has recommended the addition of borax. But as this latter ſalt contains an exceſs of alkali, it is obvious that the acid of the tartar would be neutralized, and a very different ſalt would be produced, namely, the tartrite of potaſh and ſoda, or Rochelle ſalt, which will be preſently deſcribed, and which of itſelf is highly ſoluble without the aſſiſtance of borax. It appears however that ſimple boracic acid[g] has the power of rendering four times its weight of cream of tartar ſoluble in as little as five or ſix parts of hot water, and probably without effecting any decompoſition of the tartar, ſince the boracic acid is known to be remarkably weak in its affinity for the ſeveral baſes.

If a ſolution of cream of tartar in water is expoſed to the air for a length of time, it gradually becomes turbid, a number of mucous flocculi are depoſited, and in the courſe of ſome months it ceaſes to be acidulous, after which it becomes ſenſibly alkaline to the taſte and to chemical teſts, and it is finally converted into a weak ſolution of carbonat of potaſh, the tartareous acid totally diſappearing, and carbonic acid taking its place. Fire operates a more rapid deſtruction of the tartareous acid, for if cream of tartar is calcined in an open fire with a red heat, it firſt ſoftens, blackens, becomes of a paſty conſiſtence, the acid burns off with flame and ſmoke, and finally a white carbonat of potaſh is left. The alkali procured in this way is very pure, and is often obtained for the laboratory by moiſtening crude tartar or cream of tartar to the conſiſtence of ſtiff paſte, wrapping up ſmall parcels of it in brown paper, and arranging them in a grate or furnace of any kind with charcoal, and kindling it. After the charcoal has burnt out, the tartar is converted into lumps of carbonat of potaſh, which ſtill cohere, and may be readily picked out of the aſhes of the charcoal. A very pure carbonat of potaſh may alſo be made by deflagrating in a red-hot crucible equal parts of nitre and cream of tartar.

This ſalt is compoſed, according to Thenard,[h] of 57 per cent. of tartareous acid, and 33 of potaſh, the remaining 10 parts being chiefly water of cryſtallization. Of theſe 57 parts of acid, 20 are in exceſs, ſo that the compoſition of the ſalt may be ſtated, in a different manner, to be 70 per cent. of tartrite of potaſh, and 20 of tartareous acid. The mode of analyſis will be mentioned in the next ſection.

Cream of tartar is decompoſed by lime and barytes, and probably by ſtrontian, and cauſtic potaſh is left in the ſolution.

TARTRITE OF POTASH, or *Soluble Tartar.* This ſalt, which is compoſed of tartareous acid and potaſh in mutual ſaturation, is prepared the moſt conveniently by adding cream of tartar to a hot ſolution of carbonat of potaſh. A briſk effervſcence takes place, and the addition of the cream of tartar ſhould be continued till this ceaſes, after which the ſolution ſhould be boiled down till a pellicle appears on the ſurface, and then left to cryſtallize by cooling. The tartrite of potaſh then ſeparates generally in the form of parallelipepids, with dihedral ſummits. When this ſalt is prepared in the large way for medicinal purpoſes the evaporation is continued nearly to dryneſs, with frequent ſtirring, by which the ſalt is obtained in a ſhapeleſs granular maſs.

Tartrite of potaſh has a bitteriſh ſaline taſte, is ſomewhat deliqueſcent, and is ſoluble in about four parts of cold water, ſo that in ſolubility it remarkably exceeds cream of tartar.

It is partially decompoſed by the ſtronger acids, which abſtract a portion of its alkali, whilſt the whole of the tartareous acid remains in union with the remaining alkali in the form of cream of tartar, as already mentioned in the preceding ſection. Tartareous acid dropped into a moderately ſtrong ſolution of tartrite of potaſh alſo cauſes an immediate depoſit of cream of tartar.

Tartrite of potaſh contains, according to Thenard,[i] 48 per cent. of tartareous acid, and 43 of potaſh, the reſt being chiefly water of cryſtallization. This he eſtimates, 1ſt, by heating the ſalt to perfect dryneſs, avoiding its decompoſition; 2d, by diſſolving the remainder in water, and decompoſing it by acetited lead, and collecting the tartrite of lead thus produced, (which laſt by previous experiments, he finds to conſiſt of 34 per cent. of tartareous acid, and 66 of oxyd of lead); and, 3d, by evaporating the remaining ſolution of acetite of potaſh to dryneſs, calcining it, diſſolving the reſidual carbonat of potaſh in nitric acid, and converting it to nitrat of potaſh, which laſt he eſtimates to contain 53 per cent. of potaſh. By the 1ſt proceſs therefore the water of cryſtallization is aſcertained; by the 2d, the tartareous acid; and by the 3d, the potaſh.

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[g] Laſſone.

[h] An. Chim. tom 41.

[i] Ibid.

Tartrite of Potaſh and Soda. Salt of Seignette. Rochelle Salt.

This is a triple cryſtallizable ſalt firſt diſcovered by a perſon of the name of Seignette, at La Rochelle, and introduced by him into medicine. It is prepared in the following way: boil ſome water, throw into it about a fifth of its weight of cream of tartar, and then add by degrees a quantity of carbonat of ſoda, as long as any effervescence is excited. In proportion as the exceſs of acid in the cream of tartar becomes ſaturated with the ſoda, the ſalt gradually diſappears, and is finally held in perfect ſolution in the liquid. Evaporate the whole to the conſiſtence of ſyrup, and by cooling it will yield the triple tartrite or Rochelle ſalt, in large tranſparent beautiful cryſtals, generally of the form of eight-ſided priſms. Theſe are often found divided longitudinally through the axis.

This ſalt is perfectly neutral, diſſolves in about five parts of water, has a bitteriſh ſaline taſte, and ſomewhat effloreſces by expoſure to the air. It is totally decompoſed by barytes and lime, and the ſupernatant liquor then contains a mixture of potaſh and ſoda. It is compoſed, according to Vauquelin, of about 54 per cent. of tartrite of potaſh and 46 of tartrite of ſoda.

It is decompoſed, like the ſimple tartrite of potaſh, by the ſtronger acids, and cream of tartar is produced.

Tartrite of Potaſh and Ammonia.

This triple ſalt is prepared in the ſame general manner as the preceding, by ſaturating the cream of tartar with carbonat of ammonia; and by evaporation and cooling the triple ſalt is ſeparated. When expoſed to the air it effloreſces, and after a time loſes its ammonia, and returns to the ſtate of ſimple cream of tartar.

Tartrite of Potaſh and Lime, Barytes, &c.

Though lime will compleatly decompoſe any alkaline tartrite, as is ſhewn in the preparation of the tartareous acid, there appears to exiſt a certain affinity between tartrite of potaſh and lime, which tends to the formation of a triple ſalt. Thus though ſimple tartrite of lime is inſoluble in cold water, no precipitate is produced by the affuſion of a ſmall quantity of lime-water into a cold ſolution of tartrite of potaſh, which muſt therefore be owing to the tartrite of lime, then formed, being rendered ſoluble by the remaining tartrite or rather ſub-tartrite of potaſh [j] Even when cream of tartar is as completely as poſſible decompoſed by lime in ſubſtance, in the proceſs of obtaining the acid the cauſtic alkaline liquor, ſupernatant over the precipitated tartrite of lime, ſtill holds a ſmall quantity of the latter in ſolution, as has been remarked by Vauquelin, which may be conſidered as a triple ſalt of tartareous acid, lime, and potaſh, the latter being in very large exceſs.

The ſame applies to barytes and ſtrontian, the ſolutions of which do not immediately give a precipitate with tartrite of potaſh; and even if tartrite of barytes or of ſtrontian recently formed and ſtill wet be put into a ſolution of tartrite of potaſh, it is ſoon diſſolved; though the mere quantity of liquid preſent would be entirely unable to effect a ſolution. There is therefore ſuch a ſtrong affinity between tartrite of potaſh and theſe earthy tartrites as may perhaps entitle us to conſider theſe compound ſolutions as triple ſalts, though they have not been obtained in a cryſtallized form like the triple tartrite of potaſh and ſoda.

Alumine unites with ſtill greater eaſe with tartrite of potaſh: for when this earth, recently precipitated from alum by a cauſtic or carbonated alkali, and ſtill wet, is transferred to a ſolution of tartrite of potaſh, it readily diſſolves therein, and forms an uncryſtallizable compound which is not rendered turbid by any addition of potaſh or its carbonat. This laſt circumſtance might lead to the ſuppoſition that alumine has a ſtronger affinity for tartareous acid than potaſh has, but it is contradicted by the fact, that in this caſe there is not the leaſt exceſs of potaſh in the liquid; ſo that the alumine does not diſplace the alkali from the tartareous acid, but unites with them both into a triple compound. The Rochelle ſalt has the ſame habitude with alumine as the ſimple tartrite of potaſh, which therefore forms a quadruple compound of tartareous acid, potaſh, ſoda, and alumine.

Tartrite of Soda. When the tartareous acid is ſaturated with ſoda, a ſalt is produced, which by due evaporation may be obtained in ſmall needled cryſtals, and is the tartrite of ſoda. This ſalt (with which the Rochelle ſalt was formerly confounded) is not very ſoluble in water. When tartrite of potaſh is added to this ſalt, each in ſaturated ſolution, large cryſtals of the triple tartrite, or Rochelle ſalt are immediately depoſited.

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[j] Thenard.

A Super-Tartrite of Soda is formed by partially ſaturating tartareous acid with ſoda; and alſo by adding a ſtrong acid to the ſaturated tartrite, which, analogous with the cream of tartar, is leſs ſoluble than the ſaturated compound, and therefore precipitates. Tartareous acid however will not form an acidulous tartrite (at leaſt not viſibly) when added to the ſulphat and other ſalts of ſoda, as it will with the ſalts of potaſh.

TARTRITE OF AMMONIA.

This ſalt is formed by ſaturating the tartareous acid with ammonia or its carbonat. It cryſtaliizes readily, and is decompoſed by the fixed alkalies and alkaline earths.

A *Super-Tartrite of Ammonia* is formed in a ſimilar manner to the ſuper-tartrite of ſoda, and with the ſame exception of the acid not viſibly decompoſing the other ammoniacal ſalts.

EARTHY TARTRITES.

When tartareous acid is added to any ſoluble ſalt of lime, or lime to a ſoluble tartareous ſalt, a white precipitate is produced which is the *Tartrite of Lime.* This earthy ſalt is inſoluble in mere water at a common temperature, but it diſſolves readily in an exceſs of its own, or of any other acid that does not decompoſe it; ſuch as the acetous or muriatic. It alſo is rendered ſoluble in water by the addition of potaſh as already mentioned under the head of Tartrite of potaſh. When heated ſtrongly in an open fire the whole of the acid is conſumed, and carbonat of lime remains.

Tartrite of Barytes and Strontian are formed in the ſame manner as tartrite of lime. They are not however ſo inſoluble in water as this ſalt, and the tartrite of ſtrontian will even cryſtallize from its hot-ſaturated ſolution by cooling.

With *Magneſia* and *Alumine* this acid forms very ſoluble compounds, which do not cryſtallize by evaporation, but dry up into a gummy maſs.

Of all the tartrites, the cream of tartar is the only one employed in the arts, which, with the tartrite of potaſh and Rochelle ſalt, is alſo uſed in medicine.

TELESIA. See CORUNDUM.

TELLURIUM.

Tellurium is a brittle metal, nearly as fuſible as lead, and eaſily volatilizable; it burns rapidly before the blowpipe with a greeniſh-blue flame, and is not much more than ſix times as heavy as water.

§ 1. *Ores of Tellurium.*

Tellurium has hitherto been found only in the native metallic ſtate, and therefore, properly ſpeaking, there is but one ſpecies; as, however, it occurs in combination, or at leaſt mixed, with gold and other metals in various proportions, this ſpecies may conveniently be divided into the four following ſub-ſpecies.

Sp. 1. Native Tellurium.

1 *Subſp.* White native Tellurium.—*Gediegen Sylvan*, Wern. *Tellure natif aurifère et ferrifère*, Hauy. *Sylvane natif*, Broch. *Sylvanite*, Kirw. *Aurum paradoxum*, or *problematicum* of the older writers.

Its colour is tin-white, paſſing into ſilver-white: it occurs maſſive and diſſeminated: it poſſeſſes a ſtrong metallic luſtre: its fracture is foliated: it preſents ſmall granular diſtinct concretions: it is ſoft and ſlightly ductile. Sp. gr. 5.7 to 6.1.

Before the blowpipe it melts, inflames, and is for the moſt part volatilized in the form of a denſe white vapour, its component parts, according to Klaproth, are

92.55	Tellurium
7.2	Iron
0.25	Gold
100..	

The proportion of gold in this ſubſtance is liable to conſiderable variation; one ſpecimen, examined by Klaproth, afforded him no leſs than 9 per cent.

It has hitherto been found only at Fatzebay, in Tranſylvania, where it has long been worked as a gold ore; it is at preſent however very ſcarce. It forms veins in tranſition mountains, particularly gräuwakke and tranſition limeſtone, and is accompanied by quartz, lithomarga, iron, pyrites, blende, and galena.

It was for a long time miſtaken for auriferous antimony, to which it bears a great reſemblance.

2 *Subſp.* Grey native Tellurium.—*Schrifterz*, Wern. *Sylvane graphique*, Broch. *Tellure natif graphique*, Hauy. *Aurum graphicum*, of the older writers.

Its colour is light ſteel-grey. It occurs maſſive, and cryſtallized in flattened tetrahedral or hexahedral priſms, either with or without tetrahedral ſummits. The cryſtals are ſmall and arranged in rows, generally on the ſurface of ſome other mineral: it not unfrequently happens, that to the extremities of the priſms are attached others, at right angles, giving the whole row the appearance of a line of Turkiſh letters or Perſepolitan characters; from which circumſtance is derived the trivial name of this mineral. Externally it is ſmooth, and ſhining with a metallic luſtre. Its fracture is fine-grained, uneven: its fragments are indeterminately angular, ſharp-edged. It is ſoft, brittle, and eaſily frangible. Sp. gr. 5.72. It is compoſed, according to Klaproth, of

60	Tellurium
30	Gold
10	Silver
100.	

It occurs at Offenbanya, in Tranſylvania, in veins in a mountain compoſed of ſienitic porphyry and granular lime-ſtone, and is accompanied by quartz, iron pyrites, fahlerz, and blende.

3 *Supſp.* Yellow native Tellurium.—*Weiſs Silvanerz*, Wern. *Silvane blanc*, Broch. *Tellure natif aurifère et plombifère*, Hauy. *Gelberz*, Karſten.

Its colour is ſilver-white, inclining ſtrongly to braſs-yellow, and ſometimes to grey. It occurs diſſeminated, and in minute, imbedded, acicular tetrahedral priſms. Externally it has a bright metallic luſtre, internally it is but feebly-ſhining. Its longitudinal fracture is foliated, its croſs fracture is ſmall-grained, uneven. It is ſoft, and moderately brittle. Sp. gr. 10.67. It is compoſed, according to Klaproth, of

44.75	Tellurium
26.75	Gold
19.5	Lead
8.5	Silver
0.5	Sulphur
100.	

It is found at Nagyag, in Tranſylvania, in quartz and brown ſpar, accompanied by the following ſubſpecies, and by blende, fahlerz, and copper pyrites.

4 *Subſp.* Black native Tellurium. *Nagyagerz*, Wern. *Silvane lamelleux*, Broch. *Tellure natif aurifère et plombifère*, Hauy. *Blattererz*, Karſten.

Its colour is between iron-black and deep lead grey. It occurs in maſs, diſſeminated, or cryſtallized in thin longiſh hexagonal tables, cellularly accumulated. Externally it is brightly ſhining; internally, leſs ſo, with a metallic luſtre. Its fracture is curved foliated; the maſſive variety preſents coarſe-grained diſtinct concretions. It ſoils the fingers a little; is ſoft, ſectile, flexible in thin laminæ. Sp. gr. 8.9. It is compoſed, according to Klaproth, of

54.	Lead
32.2	Tellurium
9.	Gold
0.5	Silver
1.3	Copper
3.	Sulphur
100.	

It occurs at Nagyag, in Tranſylvania, in a matrix of quartz and red mangane ſe, accompanied by galena, iron pyrites, blende, antimony, fahlerz, and realgar.

§ 2. *Analyſis of Ores.*

The beſt analyſes that we poſſeſs of the ores of Tellurium, are by Klaproth;[a] to whom indeed the diſcovery of this metal is principally owing. In order to decompoſe the firſt ſubſpecies, this excellent chemiſt purſued the following method.

(*a*) The ore, ſeparated as much as poſſible from its ſtony matrix, and finely pulverized, was digeſted in ſix parts of warm muriatic acid, to which were added, cautiouſly and at intervals, three parts of nitric acid. The compound acid acted violently on the ore, and took up the whole of it except the quartzoze matrix.

(*b*) The acid ſolution being diluted with as much water as it would bear without decompoſition, was combined with cauſtic fixed alkali, upon which a copious precipitate fell down; more alkali was then added, till the whole of the precipitate that was reſoluble in this menſtruum was taken up. There remained behind a dark-brown ſlimy reſidue, conſiſting of the oxyds of gold and iron.

(*c*) The reſidue of *b* was then diſſolved in nitro-muriatic acid, to which was afterwards added, drop by drop, nitrat of mercury, prepared in the cold, as long as the precipitate thus formed appeared of a brown colour. This precipitate, conſiſting of gold and muriat of mercury, was then pretty ſtrongly ignited in a crucible with borax, by which the mercury was driven off, and a button of pure *gold* remained.

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[a] Analyt. Eſſ. vol. ii. p. 1.

(*d*) To the nitro-muriatic ſolution *c*, was now added cauſtic alkali, by which the oxyd of *iron* was thrown down.

(*e*) The alkaline ſolution *b* was accurately ſaturated with muriatic acid, and then heated, by which a white heavy powder was obtained; which, after being waſhed in a mixture of equal parts of alcohol and water, and then gently dried, was pure oxyd of *Tellurium*.

The ſecond ſubſpecies was treated in the following manner.

(*a*) The finely pulverized ore was digeſted in nitro-muriatic acid till nothing more was taken up.

(*b*) The inſoluble reſidue, conſiſting of quartz and muriat of ſilver, was fuſed with five times its weight of carbonated ſoda, by which the *ſilver* was obtained in the metallic ſtate.

(*c*) The nitro-muriatic ſolution being concentrated by evaporation, was largely diluted by alcohol, upon which the oxyd of *Tellurium* precipitated; and this being re-diſſolved in muriatic acid, was obtained in black metallic flocculi, by means of a bar of poliſhed iron.

(*d*) The nitro-muriatic ſolution *c*, after ſeparation of the tellurium, contained only *gold*, which was procured by the addition of a ſolution of green ſulphat of iron.

The analyſis of the third ſubſpecies was ſomewhat more complicated.

(*a*) 400 grains of the pulverized ore were digeſted with nitric acid, till every thing ſoluble in this fluid had been taken up.

(*b*) The nitrous ſolution was combined with muriatic acid, as long as any precipitation took place; by this there was obtained 51 grs. of a white powder, of which 43 grs. were again reſoluble in boiling water. The inſoluble portion, amounting to 8 grs. was muriated *ſilver*.

(*c*) The ſolution containing the 43 grs. above mentioned, was concentrated by gradual evaporation, and afforded delicate needleform cryſtals of muriated *lead*.

(*d*) The reſidue of *a*, inſoluble in nitric acid, was then treated with nitro-muriatic acid, as long as any thing was taken up: the ſolution was mixed with the nitro-muriatic ſolution *b*, and reduced by evaporation till it ceaſed to depoſit muriat of *lead*: 11 grs. were thus obtained.

(*e*) To the concentrated ſolution *d*, was added cauſtic potaſh in exceſs, which threw down a copious blackiſh-brown precipitate; this being ſeparated, the alkaline liquor was ſaturated with muriatic acid, and the white precipitate thus obtained being again diſſolved in muriatic acid, and then precipitated by means of a ſtick of zinc, afforded 85 grs. of metallic *Tellurium*.

(*f*) The blackiſh-brown precipitate of *e* was diſſolved in nitro-muriatic acid, and the liquor was nearly ſaturated with cauſtic potaſh; nitrated mercury was then added, till the precipitate began to be white. This precipitate being ſeparated by the filter, and waſhed, the filter, with its contents, was ignited in a crucible, and a little nitre being added, the fire was increaſed, and a button of pure *gold* was thus obtained, weighing 50.75 grs.

(*g*) The remainder of the nitro-muriatic ſolution *f* was ſaturated with carbonated potaſh, and a precipitate was obtained, conſiſting of oxyd of *mangane*ſ*e*, mixed with carbonated *lime* and a little *alumine* and oxyd of *iron*.

(*h*) The inſoluble reſidue of *d*, weighing 120.5 grs. and conſiſting chiefly of quartz, was gently heated, by which it loſt about 1 gr. which was *ſulphur*: being then mixed with four times its weight of carbonated potaſh, and fuſed, there was obtained a button of *ſilver*, weighing 10.125 grs.

The fourth ſubſpecies was analyſed in the following manner.

(*a*) 1000 grs. of the pulverized ore were digeſted with 10 oz. of muriatic acid, to which was added, by degrees, a little nitric acid: this being poured off, 5 oz. more of muriatic acid were added, by which every thing ſoluble in this menſtruum was taken up: to the filtered ſolution boiling water was added, to re-diſſolve the muriat of lead which had begun to be depoſited.

(*b*) Of the inſoluble reſidue a part had cohered into a maſs, and was for the moſt part ſulphur, weighing 17.5 grs.; being gently ignited, it left behind 3.5 grs. of a blackiſh matter which was diſſolved in muriatic acid, and added to the foregoing ſolution. Hence the *ſulphur* of the ore amounted to 14 grs.

(*c*) The remainder of the inſoluble reſidue was for the moſt part quartz, and weighed 440.5 grs. Being melted with four times its weight of carbonated potaſh, there appeared, on breaking the maſs, a few globules of ſilver, amounting to about 2.5 grs. equivalent to 3.5 grs. of muriated ſilver; ſo that the quartzoze matrix was equal to 437 grs.

(*d*) The ſolution *a* being concentrated by evaporation, cryſtals of muriated *lead* were depoſited, to the amount of 330 grs. equivalent to 248 of metallic lead.

(*e*) Having thus ſeparated the lead, the remainder of the ſolution was largely diluted with alcohol, by which a white oxyd of *Tellurium* was thrown down. This oxyd being rediſſolved by muriatic acid, and again precipitated by cauſtic ſoda, afforded 178 grs. of oxyd, equivalent to 148 grs. of reguline tellurium.

(*f*) The alcoholic ſolution was next diſtilled by which the alcohol was ſeparated; the reſidual fluid being diluted with water, was treated with nitrat of mercury, in the way already deſcribed, by which a button of *gold*, weighing 41.5 grs. was obtained.

(*g*) The reſidual fluid of *f* was ſaturated with carbonated ſoda and boiled, by which a bluiſh-grey precipitate was obtained: by digeſtion in muriatic acid it diſſolved, and oxymuriatic acid gas was produced: the muriatic ſolution being then ſuper-ſaturated with carbonated ammonia, there was depoſited carbonated *mangane ſe*, mixed with iron, to the amount of 92 grs.

(*h*) The ammoniacal ſolution was of a blue colour, upon which it was ſuper-ſaturated with ſulphuric acid, and a plate of iron being immerſed in the fluid, there was depoſited 6 grs. of *copper*.

§ 3. *Phyſical and Chemical Properties.*

Reguline tellurium may be obtained by heating the white oxyd of this metal in contact with carbonaceous matter: but as tellurium is both eaſily volatilizable and readily inflammable, certain precautions are neceſſary to enſure the ſucceſs of the experiment. If the reduction is attempted in a crucible, in proportion as the metal is deoxydated, it riſes in vapours through the luting, and burns with a blue flame; ſo that by the time the oxyd is reduced, the metal will have eſcaped. In order to ſucceed perfectly, the following method muſt be purſued: the oxyd, being previouſly well mixed with 8 or 9 per cent. of charcoal powder, is to be put into a ſmall glaſs retort with a receiver adapted, and heated gradually to a low ſtate of ignition: as ſoon as it arrives at this point, a ſudden and conſiderable production of carbonic acid takes place, a little of the mixture paſſes into the receiver, and metallic globules will be obſerved adhering to the neck of the retort, as in the diſtillation of mercury. The apparatus being then cooled ſlowly, the tellurium will be found at the bottom of the veſſel, with a clean bright cryſtalline ſurface, perfectly reduced and unmixed with charcoal. 100 parts of white oxyd afford about 83 parts of metal.

The colour of pure tellurium is tin-white, paſſing into lead-grey: it has a brilliant metallic luſtre: its fracture is ſtraight foliated, and by ſlow cooling it is ſuperficially cryſtallized: the form of its cryſtals however has not been aſcertained. It is very brittle, and eaſily pulverizable. Its ſp. gr. is = 6.115. It melts at nearly the ſame temperature as zinc does; and when ignited it begins to be volatilized. By expoſure to the blow-pipe on charcoal, it inflames with a violence approaching to detonation, burning with a vivid blue flame, light-green on the edges, accompanied by a heavy white ſmoke, which is the oxyd produced by the combuſtion.

Tellurium combines readily by fuſion with its own weight of ſulphur, and the reſult is a lead-coloured ſtriated maſs, with a metallic luſtre.

By ignition in a retort, a part of the ſulphur ſublimes, carrying with it a ſmall proportion of metal, by which it acquires a blackiſh-brown colour.

Nitric acid diſſolves tellurium, and the reſult is a clear colourleſs ſolution, capable of affording, by concentration and cooling, ſlender needle-ſhaped cryſtals.

Nitrat of tellurium is not decompoſable by water.

Muriatic acid by itſelf has little or no action on tellurium, but when aſſiſted by a ſmall proportion of nitric acid, the ſolution goes on rapidly. The reſult is a clear colourleſs ſolution, from which a white muriated oxyd, or ſubmuriat, is precipitable on the addition of water; in a larger proportion, however, of this fluid, it is again ſoluble. If, on the other hand, the concentrated muriat is diluted with alcohol inſtead of water, no tellurium remains in ſolution.

Concentrated ſulphuric acid, by digeſtion without heat, takes up a ſmall portion of tellurium, and acquires thereby a deep amethyſtine red colour. On the addition of a little water, a black flocculent precipitate takes place, and the ſolution loſes its colour. The colour of the ſolution is likewiſe deſtroyed by mere heat, a white oxyd being ſeparated.

If, however, the ſulphuric acid is previouſly diluted with water, and mixed with a few drops of nitric acid, a conſiderable portion of tellurium is taken up, and the ſolution is without colour, and not decompoſable by the addition of water.

The acid ſolutions of tellurium are all decompoſed by the alkalies; but if theſe laſt are added in exceſs, the oxyd is again taken up, whether a pure or carbonated alkali is made uſe of.

Pruſſiat of potaſh, if pure, does not decompoſe the ſalts of tellurium.

The alkaline hydro-ſulphurets throw it down in the form of a black powder.

Tincture of galls produces a flocculent pale yellowiſh brown precipitate.

Zinc and iron precipitate tellurium in its metallic ſtate from all its acid ſolutions. Tin and antimony likewiſe decompoſe, in a ſimilar manner, the muriat of this metal. Phoſphorus alſo ſeparates the metal from its muriatic ſolution.

The white oxyd of tellurium, if heated by the blowpipe on charcoal, is reduced with a rapid efferveſcence to the metallic ſtate, and is immediately after volatilized by combuſtion, and converted again to an oxyd. If, on the other hand, it be treated without any inflammable matter in a retort, it fuſes into a pale yellow ſtriated maſs.

Tellurium is not made any uſe of, either in the metallic or in any other ſtate.

TERRA FOLIATA TARTARI. See ACETITE *of Potaſh.*

TERRA FOLIATA CRYSTALLIZATA. See ACETITE *of Soda.*

TERRA JAPONICA. See CATECHU.

TERRA MERITA. See TURMERIC.

THERMOMETER. *See the Appendix.*

THONSCHIEFER. ARGILLACEOUS SCHISTUS. SLATE. ARGILLITE.

This mineral may be divided into the three following ſubſpecies.

1 *Subſp.* Common argillaceous ſchiſtus.—*Thonſchiefer*, Wern. *Argillite*, Kirw. *Schiſte argilleux*, Broch.

Its colour is ſmoke-grey, bluiſh or aſh-grey, greeniſh, reddiſh, or blackiſh grey; ſometimes alſo fleſh-red, reddiſh-brown, yellowiſh-brown, or olive-yellow. The colour is for the moſt part uniform, but it ſometimes preſents ſpots, bands, and dendritical delineations. It occurs in maſs, diſſeminated, or in rounded fragments. Its luſtre is ſilky or reſinous, and varies from glimmering to ſlightly ſhining. Its fracture is ſlaty, generally ſtrait, but ſometimes curved or undulating; ſome varieties are ſo compact as to preſent a dull earthy fracture. Its fragments are tabular or rhomboidal, rarely large ſplintery. It varies from very ſoft to moderately hard, but even the hardeſt may readily be ſcratched by a knife. It is eaſily frangible, but not very brittle. It gives a greyiſh-white ſtreak.

It is compoſed of ſilex, alumine, and oxyd of iron, with variable proportions of carbonated lime and magneſia. It is largely uſed for covering houſes, and the ſtrait-foliated bluiſh-grey varieties are employed as writing ſlates. The ſofter and more compact varieties are made into ſlate pencils.

2 *Subſp.* Hone ſlate.—*Novaculite*, Kirw. *Wetzſchiefer*, Wern. *Schiſte a aiguiſer*, Broch.

Its colour is greeniſh-grey, or ſmoke-grey, paſſing into olive and mountain-green. It occurs in maſs, and has a glimmering luſtre. Its fracture in the great is ſlaty, in the ſmall ſplintery. Its fragments are tabular. It is more or leſs tranſlucent on the edges. It is moderately hard, and not very frangible. Sp. gr. 2.72.

It does not efferveſce with acids, neither is it fuſible by the blow-pipe without addition. It has not been regularly analyſed.

It is cut into hones for ſharpening the finer kinds of ſteel inſtruments.

It occurs at Lauenſtein in Bareith, at Seifendorf in Saxony, in Bohemia, and the Levant (whence it is called Turkiſh hone); alſo in the valley of Llanberris in North Wales.

3 *Subſp.* Black chalk.—*Zeichenſchiefer*, Wern. *Schiſte a deſſiner*, Broch.

Its colour is greyiſh or bluiſh-black. It occurs in maſs; the longitudinal fracture is ſlaty and glimmering, the croſs fracture earthy and dull. Its fragments are tabular or ſplintery. It ſtains the fingers, and gives a ſomewhat gloſſy grey ſtreak. It is meagre, but ſmooth to the touch; is ſoft and very eaſily frangible.

Before the blow-pipe, without addition, it acquires a thin varniſh, but does not melt. Its component parts, according to an analyſis by Wiegleb, are

64.	Silex
11.25	Alumine
11.	Carbon
2.75	Oxyd of Iron
7.5	Water
96.5	

It is employed for drawing and writing on paper and other materials.

The beſt kinds come from Italy; it is alſo met with in Spain, France, Bareith, and the iſland of Iſla in the Hebrides.

Of the above ſubſpecies, the firſt, namely, common argillaceous ſchiſtus, is the moſt abundant. It belongs both to the primitive, tranſition, and ſecondary rocks, and occurs in mountain beds, often of vaſt extent. It incloſes and ſometimes alternates with beds of chlorite ſlate, hone ſlate, alum ſlate, and black chalk, of which the two former peculiarly characterize the primitive and tranſition argillaceous ſchiſtus. The primitive appears generally to reſt upon micaceous ſchiſtus, and is occaſionally mixed with quartz, mica, hornblende, black ſchorl, garnet, pyrites, granular limeſtone, and calcareous ſpar. It alſo contains various metallic ores, either in veins or beds. The quickſilver mines of Idria are in primitive argillite, ſo is the vaſt bed of copper and iron pyrites forming the Parys mine in Angleſey.

Tranſition argillite has not been much examined: the greater part of the ſlate of North Wales appears to belong to this formation, where it reſts upon grünſtein, and appears to contain no extraneous minerals, except veins of quartz and calcareous ſpar, with blende and galena. Secondary argillite contains impreſſions of organized bodies and figured pyrites: it often reſts upon ſecondary limeſtone, as is the caſe in Derbyſhire.

THUMERSTEIN. Thumerſtone, *Kirw.* Pierre de Thum, *Broch.* Axinite, *Hauy.*

The colour of this mineral is clove-brown, paſſing into violet-blue, and yellowiſh or greeniſh grey. It occurs in maſs, diſſeminated and cryſtallized. The primitive form of its cryſtals is a ſtrait rhomboidal priſm, the alternate angles of which meaſure reſpectively $101\frac{1}{2}^\circ$ and $78\frac{1}{2}^\circ$. The vertical edges of the priſm, correſponding with the acute angles, are generally, however, more or leſs truncated. Sometimes the priſms are ſo ſhort as to be nearly tabular, and are then often cellularly aggregated. The faces of the primitive cryſtal are ſtriated, but all the ſecondary planes are ſmooth. Externally the cryſtals have a bright vitreous luſtre; internally they are generally gliſtening. The fracture is ſmall conchoidal, in ſome varieties paſſing into ſplintery and fine-grained uneven. When in maſs, it is uſually compoſed of thin teſtaceous diſtinct concretions. It varies from ſemitranſparent to tranſlucent on the edges. Its hardneſs is nearly equal to that of quartz; it is brittle and very eaſily frangible. Sp. gr. 3.2 to 3.3.

It melts before the blowpipe without addition into a greeniſh white ſemitranſparent glaſs; but on charcoal to a black glaſs. It has been analyſed by Klaproth[a] and Vauquelin[b], with the following reſults.

	Klapr.	Vauq.
Silex - - -	52.7	44.
Alumine - -	25.6	18.
Lime - - -	9.4	19.
Oxyd of Iron -	9.	14.
Ditto Manganeſe	0.6	4.
	97.3	99

The proportions of this mineral as ſtated by the two able chemiſts juſt mentioned, differ from each other very conſiderably, and on comparing the methods purſued by each in performing the analyſis, it will we believe, be generally allowed that Vauquelin's is the leaſt ſubject to error. With regard, however, to the oxyd of iron, the difference is more apparent than real, Klaproth ſtating it as magnetic oxyd, and Vauquelin as red oxyd; whereas, if in each analyſis it was brought to the latter ſtate, Klaproth's 9 grs. ſhould be raiſed to 12.6 grs.

Thumerſtein occurs only in primitive mountains, and is accompanied by aſbeſtos, actynolite, calcareous ſpar, quartz, felſpar, and ſometimes with ſulphur, arſenical pyrites, and native biſmuth. The maſſive variety is met with at Thum in Saxony (whence is derived the German name of this mineral.) It occurs cryſtallized near Oiſans in Dauphiné, at Kongſberg in Norway; alſo in Spain, Savoy, and Cornwall.

TIN. Zinn, *Germ.* Etain, *Fr.*

Tin is a metal of a ſilver-white colour, very ductile and malleable, gives out while bending a peculiar crackling noiſe, is fuſible at a heat much leſs than that of ignition: is ſlowly ſoluble in muriatic acid, and by dilute nitric acid is rapidly converted into a white oxyd.

§ 1. *Ores.*

Sp. 1. TINSTONE. Zinnſtein, *Wern.* Pierre de Etain. Mine d'Etain commune, *Broch.*

Its uſual colour is browniſh-black, paſſing into clove-brown, blackiſh, rediſh or yellowiſh-brown: ſometimes alſo it occurs wine-yellow, ſmoke-grey, yellowiſh-grey and greyiſh-white. It occurs in maſs, diſſeminated, in rounded fragments, and cryſtallized. Its primitive form is ſuſpected by Hauy to be the cube: the forms under which it actually appears are,

1. A rectangular tetrahedral priſm, terminated at each extremity by a tetrahedral pyramid, the faces of which are iſoſceles triangles.

2. The preceding, with the longitudinal edges of the priſm truncated.

3. Var. 1. with the longitudinal edges both of the priſm and pyramid truncated, whence reſults an eight ſided priſm, with eight ſided ſummits, the faces of which latter are alternately triangles and pentagons. Sometimes the priſm is doubly truncated, and then preſents ſixteen ſides, the terminating pyramids remaining as before.

4. A ſtrait eight-ſided priſm ſimilar to the foregoing, with the terminal pyramids very deeply truncated.

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[a] Anal. Eſſ. Vol. I. p. 413. Journ. des Mines, No. 23. p. 1

5. A rectangular tetrahedral priſm terminated at each extremity by a tetrahedral pyramid, the faces of which are rhombs.

6. The foregoing, with thoſe edges of the terminal pyramid that are adjacent to the priſm deeply truncated.

7. Similar to the foregoing, only the terminal pyramid is much higher, and the lateral truncatures are ſo deep as to obliterate the original rhomboidal faces, whence reſults a pyramid compoſed of eight trapeziums.

8. The ſame as the preceeding, with the points of the terminal pyramid truncated and replaced by a low eight-ſided pyramid, compoſed of alternate trapeziums and long hexagons.

9. A cryſtal originating from var. 1. in which an oblique ſection appears to have been made, and the two portions turned half round on each other, ſo as to form at each extremity two re-entering angles. Theſe half-turned or hemitrope cryſtals are of particularly frequent occurence.

The cryſtals vary much in ſize but are ſeldom large, and are almoſt always half-imbedded and grouped together in a confuſed manner. Externally they are commonly ſmooth, ſometimes ſtriated, and exhibit a bright, almoſt vitreous luſtre. Internally they are ſhining or gliſtening, with a luſtre between reſinous and vitreous. The fracture is ſmall-grained uneven, ſometimes imperfectly conchoidal, and rarely lamellar. The maſſive varieties preſent granular diſtinct concretions. It varies from ſemitranſparent to opake; gives a greyiſh-white ſtreak; is hard, affording ſparks when ſtruck by the ſteel, is brittle and eaſily frangible. Sp. gr. 6.7 — 6.97.

Before the blowpipe on charcoal it decrepitates, becomes pale and opake, and is in part reduced to the metallic ſtate. It has been analyſed by Klaproth and Lampadius with the following reſults.

Klapr. from Alternon.		Lampad. Ehrenfriederſdorf.	
77.5	—	68.	Tin
21.5	—	16.	Oxygen
0.25	—	9.	Oxyd of Iron
0.75	—	7.	Silex
100 . .		100.	

Tinſtone occurs only in the oldeſt of the primitive rocks, as granite, gneiſs, micaceous ſchiſtus, and ſome varieties of argillaceous ſchiſtus, either in veins, or beds, or diſſeminated. It is accompanied by quartz, mica, lithomarga, talc, ſteatite, fluor ſpar, chlorite, topaz, apatite, wolfram, arſenical pyrites, &c. It occurs alſo in rounded fragments in alluvial beds, forming the ſhode and ſtream tin of Cornwall.

It is found in Cornwall, in Gallicia in Spain, in the Erzgebirge on the borders of Saxony and Bohemia; in the peninſula of Malacca and the iſland of Banca in Aſia, and in Chili in South America.

It is the only ore of tin ſufficiently abundant to be worked.

Sp. 2. Wood Tin. Korniſches Zinnerz, *Wern.* Mine d'Etain grenue, *Broch.*

Its colour is hair-brown of different ſhades, paſſing into yellowiſh-grey and Iſabella-yellow; two or more colours are often arranged in parallel bands in the ſame ſpecimen. It has hitherto been found only in ſmall rolled pieces, which ſometimes are reniform, and this is probably the original form of this mineral. Externally it is rough and gliſtening; internally it has a glimmering ſomewhat ſilky luſtre Its fracture is finely fibrous, either ſtraight, bundled, or diverging. Its fragments are wedge-ſhaped or ſplintery. It occurs in large and coarſe granular diſtinct concretions, which are themſelves arranged in thin curved lamellæ. It gives a ſhining yellowiſh-brown ſtreak. It is opake, hard, brittle, and eaſily frangible. Sp. gr. 6.45.

Before the blowpipe it becomes browniſh red and decrepitates, but is not fuſed or reduced to the metallic ſtate. When ſtrongly heated in a charcoal crucible, it affords according to Klaproth about 73 per cent. of reguline tin.

This mineral has hitherto been found only in Cornwall, in the pariſhes of St. Columb, St. Roach, and St. Dennis, in alluvial beds accompanied by tinſtone. It is rare, and occurs only in ſmall pieces.

Sp. 3. Bell-metal ore. Tin pyrites. Zinnkies, *Wern.* Etain pyriteux, *Broch.*

Its colour is ſteel-grey, with a tinge of braſs-yellow, paſſing into yellowiſh-white. It occurs in maſs and diſſeminated. Internally it has a weakly-ſhining metallic luſtre. Its fracture is granular uneven, paſſing into ſmall conchoidal, and rarely, imperfectly lamellar. Its fragments are indeterminate, blunt edged. It may eaſily be ſcratched by a knife, is very brittle and eaſily frangible. Sp. gr. 4.35.

Before the blowpipe it gives out a ſulphureous odour, and fuſes eaſily into a blackiſh ſlag. It tinges borax of a yellowiſh green colour.

The proportion of tin which it contains is ſubject to conſiderable variation: the lighter is its colour and the greater is the proportion of this metal. A ſpecimen of this kind was compoſed, according to an analyſis by Klaproth, of

34	Tin
36	Copper
25	Sulphur
2	Iron
97	

It has hitherto been found only at Wheal Roch, in the pariſh of St. Agnes in Cornwall, in a vein about nine feet wide, accompanied by blende and copper pyrites.

§ 2. *Aſſay and Analyſis.*

The aſſay of tin ore is extremely ſimple. Being firſt reduced by pounding to the conſiſtence of coarſe ſand, it is ſeparated by waſhing from the ſtony matters with which it is mixed (a proceſs that may be performed with great accuracy on account of the high ſpecific gravity of the ore). A grain or two is then to be treated by the blowpipe in order to aſcertain whether any arſenic is preſent. If this is the caſe, 200 grains of the ore mixed with a little charcoal, are roaſted in a calcining teſt at a low red heat, till no arſenical vapours are any longer to be perceived; the reſidue being withdrawn from the fire is to be mixed with a little pitch and fine ſaw-duſt, and put into a crucible lined with charcoal; a cover being luted on, it is to be placed in a wind or forge furnace (the latter is the beſt) and pretty rapidly raiſed to a bright red heat: in a quarter of an hour or twenty minutes the reduction will be compleated, the crucible being then removed from the fire and cooled, there will be found in it a button of metallic tin, either entirely free from ſcoriæ, or at moſt covered with a very thin blackiſh cruſt, which may be removed by gentle hammering.

If the ore on trial with the blowpipe appear to be entirely free from arſenic, the roaſting may be omitted.

The analyſis in the moiſt way though ſomewhat more complicated, is yet upon the whole ſufficiently ſimple. The method attempted by Bergman and others, of analyſing the ores of tin by means of acids, is extremely unſatisfactory, little or nothing but the impurities being taken up by theſe menſtrua. The proper mode of treating theſe ores is by means of the fixed alkalies;[b] the diſcovery of which forms one of the numerous obligations conferred by Klaproth on analytical chemiſtry.

Tinſtone.

Specimens of this mineral from Cornwall and Bohemia were thus analyſed by Klaproth.

(*a*) 100 grs. in cryſtals were ground to a fine powder, and added to a lixivium containing 600 grs. of cauſtic potaſh. This mixture was evaporated, and then moderately ignited for half an hour in a ſilver crucible; a greyiſh-white maſs was thus obtained, to which, while yet warm, was added boiling water, which diſſolved the whole with the exception of 11 grs.

(*b*) Theſe 11 grs. were again ignited with ſix times their weight of cauſtic potaſh, and being digeſted in boiling water there remained behind only $1\frac{1}{4}$ gr. of a fine yellowiſh-grey powder.

(*c*) The alkaline ſolutions being mixed together, muriatic acid was added to ſaturation, upon which a white oxyd of tin fell down: this was rediſſolved by an exceſs of muriatic acid, and finally precipitated by carbonated ſoda. This precipitate when waſhed and dried at a gentle heat, appeared in the form of tranſparent yellowiſh lumps, with a vitreous fracture.

(*d*) This precipitate being pulverized was diſſolved in muriatic acid, and into the ſolution, previouſly diluted with two or three parts of water, was inſerted a ſtick of zinc, by which the tin was thrown down in the form of thin metallic laminæ. Theſe being waſhed and dried were fuſed in a ſmall crucible under a cover of melted tallow, and afforded a metallic button weighing 77 grs.

(*e*) The reſidue of *b* amounting to $1\frac{1}{4}$ gr. was treated with muriatic acid, with which it formed a yellowiſh ſolution: from this 0.5 gr. of tin was ſeparated by means of zinc. The remainder afforded a light blue precipitate with pruſſiat of potaſh, indicating not more than 0.25 gr. of oxyd of iron: about 0.75 gr. of ſilex was alſo procured. By adding theſe products together, and making no allowance for loſs, there will remain 21.5 grs. for the oxygen contained in the ore.

Wood-Tin is to be analyſed in the ſame manner as the preceding.

Bell Metal Ore.

This was treated by Klaproth in the following manner.

(*a*) 120 grs. being reduced to a fine powder, were digeſted in the cold for 24 hours with aqua regia, compoſed of two parts muriatic and one part nitric acids: the mixture was then digeſted for ſome time longer on a ſand bath. When the acid had entirely ceaſed to act, the ſolution was diluted with water and filtered; 43 grs. remained undiſſolved, from which by gentle ignition on a teſt there were ſeparated 30 grains of ſulphur. The reſidue, amounting to 13 grs. was digeſted in nitro-muriatic acid, by which 8 grs. were taken up. The remaining 5 grs. conſiſted of about 3 grs. of ſilex, and 1 gr. of iron, reduced to the ſtate of magnetic oxyd by roaſting with wax.

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[b] Klapr. Analyſ. Vol. I. p. 522.

b. The acid ſolutions being mixed together, carbonat of potaſh was added to ſaturation, by which there was obtained a dirty-green precipitate, which by ſubſequent ſolution in muriatic acid afforded a green fluid. A cylinder of pure tin weighing 217 grs. was immerſed into the ſolution till it became quite colourleſs, in conſequence of the precipitation of 44 grains of reguline copper.

c. This copper by briſk digeſtion in nitric acid left behind a little white oxyd equivalent to 1 grain of tin; hence the true amount of copper is equal to 43 grs.

d. The cylinder of tin during its digeſtion in the ſolution *b*, had loſt 89 grs. This ſolution was now decompoſed by a cylinder of zinc, and the metallic precipitate when waſhed and dried was mixed with tallow and charcoal powder, and moderately heated in a crucible; there were thus obtained, 1 gr. of magnetic oxyd of iron and 129 grs. of reguline tin, from which deducting 89 grs. as belonging to the cylinder, there remain 30 grs. for the amount of tin in the ore.

§. 3. *Reduction of Ores.*

The method of treating the ores of tin in Cornwall is two-fold.[c] The firſt that we ſhall mention is that to which the tinſtone from the mines or vein-tin is ſubjected; the ſecond is that by which the ſtream tin is reduced.

1. The vein-tin is procured by blaſting, and when brought to the top of the pit is in fragments of various ſizes, and mixed ſo largely with quartz, argillaceous ſchiſtus, granite, and other impurities as rarely to contain more than 2 per cent. of metal. The firſt preparation that it receives is being broken by hand hammers into pieces about the ſize of hens' eggs, after which it is ready to be ſtamped. The ſtamping-mill is of the uſual conſtruction (ſee the article GOLD) except that the ſtampers are only three in number, and in front of the trough or coffer there is inſerted a plate of tin about a foot ſquare, pierced full of holes, large enough to admit a moderate ſized knitting-needle; that ſurface of the plates which is occupied by the *rough* extremities of the holes is placed on the inſide of the trough, by which ſimple and effectual contrivance the holes are prevented from being plugged up by the ore. In proportion as the tin-ſtone is reduced to the proper degree of fineneſs it paſſes with the water through theſe holes into a labyrinth of very ſimple conſtruction; here the oxyd of tin is ſeparated from much of the lighter impurities, and by ſubſequent waſhing on a wooden table it is ſufficiently dreſſed to be ſent to the roaſting furnace; in this ſtate it is called *black tin*, and is generally mixed in conſiderable proportion with miſpickel, and iron and copper pyrites. It is now calcined at a low red heat in a large reverberatory furnace for ſeveral hours in order to volatilize the arſenic and burn off the ſulphur, (a part of this laſt after being acidified, combines with the oxyds of copper and iron). The ore comes out of the roaſting furnace of a bright ochery red colour, owing to the decompoſition and oxydation of the pyrites and miſpickel, the oxyd of tin, if the operation has been well performed having undergone not the leaſt alteration. The ore is now waſhed a ſecond time, by which nearly the whole of the impurities are ſeparated. The water employed in this proceſs being conſiderably impregnated with ſulphat of copper is reſerved, and afterwards decompoſed by the addition of pieces of old iron. The next ſtep is the reduction, properly ſpeaking; for this purpoſe a reverberatory furnace, about 7 feet long and 3½ feet wide, is charged with 7 cwt. of roaſted ore mixed with ⅕ of its *bulk* of culm (Welch ſmall-coal) no lime or any other kind of flux being made uſe of; the fire is kept up pretty briſk for about ſix hours, and the tin in proportion as it is reduced ſinks down to the bed of the furnace, being covered with a boiling hot bath of black ſcoriæ. At the expiration of this period the furnace is tapped by means of an iron bar, and the hot metal flows into a ſhallow pit at the foot of the furnace. When the whole of the metal has run out, the ſcoriæ are drawn out of the furnace with a rake, and a freſh charge is immediately thrown in. While the metal in the pit is red hot it throws up a quantity of ſlag very rich in metal, which is immediately returned into the furnace, and the melted tin after it has become ſufficiently cool is taken out with iron ladles and poured into moulds of granite, where it conſolidates, each charge affording on an average from 4 to 5 cwt. of metal. The firſt

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[c] Original Communication.

ſcoriæ are not entirely exhauſted of metal, and are therefore transferred to the ſtamping-mill, and afterwards waſhed, in order to ſeparate the richer particles, which are then mixed with the next parcel of roaſted ore.

The pigs of tin thus procured are next put without any addition, into a ſmall reverberatory furnace where they are expoſed to a very gentle heat, the pureſt part of the tin firſt melts and is drawn off, forming the common grain tin; the more refractory part containing a ſmall but variable portion of copper, arſenic, and iron, is then brought to a ſtate of fuſion, and caſt into pigs forming the common or ordinary tin.

2. The ſtream tinſtone is not, we believe, found in any other part of Europe than Cornwall. It differs from the former in its extreme purity and abſolute freedom from arſenic, and in its occurring in alluvial beds. The largeſt ſtream-tin work is at Carn, about two miles to the S. E. of Perran, not far from Redruth. It is ſituated in a valley, through which flows a ſtream, the courſe of which has been turned for the ſake of getting at the treaſure concealed beneath its bed. The workmen firſt dig through a ſtratum about fifty feet thick of clay, ſhells, and black earth, in which have been found hazel nuts, the antlers of an animal of the ſtag kind, a human ſcull, and a copper battle-axe; to this ſucceeds a layer of rounded ſtones, beneath which is the bed of tin ore in grains and lumps of various ſizes. The thickneſs of this bed varies from one to five feet, but the thickeſt part is comparatively the pooreſt. The whole of the ſuperincumbent ſtrata is cut away as the workmen proceed, ſo that the general appearance of the cavity is that of a vaſt gravel or ſand pit, near half a mile long, and about 200 feet broad, which is kept clear of water by the powerful action of two water-mill pumps. The tin ore, as it lies quite looſe, is merely ſhovelled into barrows, and wheeled to the head of the works, where it is thrown under a thin ſheet of water which waſhes away the earth, leaving the pure ore behind. After this ſimple purification the ore is ſent to St. Auſtle, a diſtance of about twenty miles, to be ſmelted. Here all the preparation for the furnace that it receives is being bruiſed and paſſed through wire ſieves containing ſixteen meſhes in the ſquare inch. The furnace employed is called in Cornwall a *blowing furnace*, and is in fact only a blaſt furnace of the ſimpleſt conſtruction, about ſeven feet high, and ſupplied with air from two cylinders, worked by an overſhot water-wheel. The only fuel made uſe of is *charcoal*, and after the furnace is fully heated it is fed at ſhort intervals with the following charge, viz. three or four ſhovelfuls of ore, and two or three half-buſhels of charcoal, no flux of any kind being employed. At the bottom of the furnace is a ſmall channel through which the reduced tin is conſtantly flowing into a pit below, accompanied by a ſmall quantity of ſlag, which is removed from time to time, and thrown again into the furnace. When the pit is full of tin it is ladled out into an iron boiler, about three feet in diameter, with a ſmall fire under it to keep the metal ſufficiently fluid: two or three large pieces of charcoal are then laid upon the tin, and plunged to the bottom by means of an iron inſtrument reſembling a wheel, with a long handle fixed in the axle. A violent ebullition is immediately excited, and a little ſlag, which was before mixed with the metal, riſes to its ſurface, and is ſcummed off. In a minute or two after, the metal is *tried*, by taking up a ladleful and pouring it again into the maſs, when if it appears quite bright like ſilver, and of an uniform conſiſtence, the purification is compleat, and nothing more is requiſite than to cool it to the proper degree, and lade it into the moulds, by which it is formed into pigs, weighing from 2 to 3 cwt. each. If the metal is poured too hot into the moulds it is apt to be brittle. Good ſtream tin affords from 65 to 75 per cent. of the very beſt and pureſt grain tin.

None of the Corniſh tin may be ſold till it has been coined; for this purpoſe a ſmall piece is cut off from every pig and aſſayed; if it appears of the requiſite purity it receives the ſtamp of the Duchy, and pays to the Prince of Wales, as Duke, four ſhillings per cwt.

§. 4. *Phyſical and Chemical Properties.*

Tin is a metal of a beautiful ſilvery whiteneſs when recently melted, but by ſhort expoſure to the air it acquires a ſuperficial tarniſh, which does not much increaſe by time. It has a ſlight and nauſeous taſte, and gives a peculiar ſmell when rubbed. It may be cryſtallized by melting a quantity and pouring out the center of the maſs after the ſides have ſolidified. Its ſpecific gravity is about 7.9. It is an extremely ſoft metal, ſcarcely if at all elaſtic, and when a piece of it is bent backwards and forwards it gives a peculiar crackling noiſe. It has very little tenacity, being in this reſpect inferior even to gold, and only ſuperior to lead. It is extremely malleable, and may readily be extended into leaves thinner than writing paper. It is the moſt fuſible of all the ſolid metals, and melts at about 442° Fahr.

It is reduced to powder for medicinal purpoſes by being melted and poured into a wooden box, rubbed with chalk on the inſide, and ſhaken violently, and afterwards waſhed to get rid of the chalk.

It is not ruſted nor apparently altered by being kept under water.

The oxydation of tin when heated in contact with air has been much examined by chemiſts. When this metal is melted in any open veſſel, as ſoon as the fuſion is compleat, the ſurface tarniſhes and wrinkles, forming a firm pellicle of a duſky grey colour, and if theſe pellicles are ſucceſſively removed as they form, the whole metal is gradually changed into them. If the whole maſs is then rubbed in a mortar with water, and the liquid immediately decanted to ſeparate ſome uncalcined particles of tin which remain entangled in the pellicles, an uniform grey-brown oxyd is produced, in which the microſcope can diſcover no particles of reguline metal, and which is tin in the firſt or loweſt ſtate of oxydation. During the firſt calcination the heat ſhould not be raiſed quite to redneſs.

If this firſt oxyd is then again heated, with conſtant ſtirring, in a broad veſſel made fully red-hot, the colour of the oxyd gradually changes to an uniform light grey, which, by continuing the heat for ſome time, becomes white, harder, and ſomewhat agglutinates, but undergoes no further alteration. If the firſt oxyd is heated pretty briſkly in this proceſs, it becomes very luminous, and actually burns with a bright flame during its further oxydation. The combuſtion of tin is alſo ſhewn more diſtinctly by heating a quantity of the metal immediately to a full red or white heat in a covered crucible, and then on removing the cover and turning aſide the cruſt of oxyd on the ſurface, the metal will burn with a very vivid flame ſomewhat like zinc, and an immediate and copious ſublimation of white oxyd. The ſame effect is ſhewn more ſpeedily by heating intenſely a little tin with the blow-pipe on charcoal, and then on ſuddenly throwing it down on a hearth, it diſperſes into a number of beautiful luminous globules.

Whilſt tin is in the act of combuſtion, the oxyd which is formed in the proceſs acquires a volatility, and viſibly ſublimes when the heat is very intenſe, but when the oxyd is already formed, it is perfectly fixed in the fire, and is with difficulty fuſible *per ſe* in the utmoſt intenſity of fire. Thus as Geoffroy has obſerved[d] if tin be placed *on charcoal*, and the focus of a powerful burning glaſs thrown on it, it inſenſibly diſſipates in ſmoke without any reſidue; but if placed on an *earthen* ſupport it firſt burns for a while with evident ſmoke, after which a thick white cruſt of oxyd forms on the ſurface, which by continuing the heat takes the form of ſmall hard tranſparent cryſtals.

The phenomena that occur on heating tin very intenſely are ſhewn by an experiment of Beaumé. He put ſome Malacca tin in a crucible, incloſed this in a muffle, and expoſed the whole to a very ſtrong heat for two hours. When cold, the upper part of the crucible was found covered with a conſiderable quantity of flowers of tin of extreme whiteneſs and ſymmetrically arranged in brilliant needles. Beneath this were many vegetations of oxyd of tin of a cauliflower form, conſiderably hard, and of a brick red. Below this was an incohering maſs of pure white oxyd of tin; under which was a ſtratum of clean tranſparent glaſs, or vitrified oxyd, of a bright garnet red; and below the latter was a portion of the reguline metal unaltered.

From all the experiments that have been made on this ſubject it appears that there are at leaſt two diſtinct degrees of oxydation of tin effected by the joint action of heat and air, the loweſt of which is formed at a heat below redneſs, and produces a duſky grey oxyd; and the higheſt, which is formed at a full red heat and with viſible combuſtion, produces an oxyd which is nearly white. The latter, when heated very intenſely, appears capable of fuſion, though with much more difficulty than the oxyds of iron, lead, and copper. With regard to the red, yellow, and green ſhades of colour, which the fuſed oxyd of tin ſometimes aſſumes, this may partly be attributed to a caſual admixture of the above metals; but if the tin was nearly pure in Beaumé's experiment, the colour of the pure vitrified oxyd of tin is a garnet red. This however does not agree with Klaproth's experiments, who found the pureſt native oxyds of tin, containing no more than a quarter per cent. of oxyd of iron, when fuſed in a clay crucible in a porcelain furnace to run into a clear glaſs, either greeniſh-grey or with a ſlight tinge of yellow, but with no tendency to the garnet-red hue. When the oxyd of tin, either by itſelf or mixed with the oxyd of lead is fuſed with the ſaline and earthy vitreſcent mixtures it gives a beautiful opake white, as we have already mentioned under the article *Enamel*. It is doubtful however whether in this proceſs the oxyd of tin is brought to compleat fuſion, and whether the opacity does not ariſe from this circumſtance.

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[d] Mem. de l'Acad. for 1738, p. 115.

It is ſomewhat doubtful whether there is any diſtinct intermediate oxyd of tin between the two that we have mentioned, or whether the ſucceſſive ſhades of colour which the firſt oxyd aſſumes during its compleat calcination, are not owing to a mixture of the perfect with the imperfect oxyd.

A preparation of the oxyd of tin is made for the purpoſe of giving the higheſt poliſh to ſteel, and to glaſs and metal mirrors, which is called *Tin Putty*. It is prepared according to Beaumé in the following way.

Some tin is melted in an iron veſſel with a low red heat, and the oxyd that forms on the ſurface is ſucceſſively removed till enough of it is procured. This is then ſpread on a red-hot muffle, and heated for half an hour, with frequent ſtirring, to compleat the calcination of any particles of tin that may be entangled in the oxyd. When cold it is powdered and ſifted, and the finer part is again calcined for ſix or ſeven hours on a muffle with a ſtronger heat, till it becomes almoſt white, and conſiderably hard, and in this ſtate it forms the tin putty.

This ſubſtance is made in this country in a ſimilar way. For the fineſt putty the pureſt grain tin is employed, which is calcined in a muffle, finely levigated, and waſhed. This is nearly white, but the ordinary and cheaper ſorts are browner, and are made by calcining old pewter, or elſe a mixture of tin and lead, or any other alloy of theſe metals, which when in mixture oxydate ſtill more readily than either of the metals ſeparately, and will eaſily take fire as ſoon as the heat is raiſed to redneſs. As the oxyd of lead is very fuſible, and the oxyd of tin very little ſo, the ſubſequent calcination in this caſe is probably made at a lower heat than when pure tin is uſed, otherwiſe the whole would run into a denſe glaſs. This preparation muſt not be confounded with glazier's putty, which is only chalk beat up with linſeed oil.

Tin is readily oxydated by nitre in the following way. Project a little of this ſalt on tin made moderately red-hot in a crucible. A very ſtrong deflagration enſues, with a brilliant white flame and a denſe white ſmoke, which latter conſiſts of part of the oxyd of tin volatilized, and will ſettle on the adjacent ſurfaces in the form of a fine white powder. Continue to project ſmall quantities of nitre on the tin as long as any effect is produced (the heat being kept up to full redneſs) by which the whole of the metal is oxydated in the higheſt degree. When cold, diſſolve out all the ſoluble part of the contents of the veſſel, and a very pure white oxyd of tin will be left behind, which is ſometimes uſed as the baſe for opake enamel colours, though this in general is a mixture of the oxyds of tin and lead made by calcination. The ſoluble part of the reſidue from the deflagration of tin and nitre, conſiſts of the undecompoſed nitre, if any, together with the potaſh of the portion which has been decompoſed, in a cauſtic ſtate, and holding a conſiderable quantity of the ſame oxyd of tin in ſolution, which may be ſeparated by ſaturation with an acid. This oxyd of tin by nitre may be prepared rather more conveniently by previouſly mixing together one part of tin filings with three parts of nitre, and projecting the mixture by ſpoonfuls into a crucible made very hot. The grey oxyd with a ſmaller quantity of nitre will anſwer equally well.

It does not appear that an exact analyſis has been made of the different oxyds of tin formed by the mere action of fire and air, but the white oxyd, which is that formed by compleat combuſtion at a ſtrong heat, is probably at the higheſt ſtate of oxygenation, and therefore in its compoſition reſembles the perfect oxyd made by nitric acid, which will be preſently mentioned.

A very marked difference is found in the chemical properties of the higher and lower oxyds of tin. The grey oxyd (or *ſub-oxyd* as it may be termed for diſtinction) made by calcination at a low heat, takes fire when brought to a full red, and aſſumes a white colour with increaſe of oxydation—it detonates with nitre, and is thus converted to the higher oxyd—it diſſolves in muriatic acid with emiſſion of hydrogen, and in dilute nitric acid—when in ſolution it gives a black brown precipitate with ſulphuret of potaſh, and a black with corroſive mercurial muriat—and it is reduced to the metallic ſtate again with the utmoſt eaſe, by being moderately heated with pitch, charcoal, or any carbonaceous matter. On the other hand, the *white or perfect oxyd* is not further changed by the action of fire except being fuſed by it when very intenſe, during which it again loſes part of its oxygen—excites no deflagration with nitre—is inſoluble in dilute nitric acid—and is not readily reduced to the metallic ſtate. There are beſides ſeveral other important differences between the ſalts and compounds of theſe two oxyds, as will be ſeen further.

Sulphuric acid diluted with about a fourth part of water, will diſſolve about a quarter of its weight of tin, when this metal is added in ſmall grains or filings, and the ſolution aſſiſted by a moderate heat. An effervescence of ſulphurous acid vapour ariſes, and ſometimes ſulphur in ſubſtance is produced[e] from the total decompoſition of part of the acid, which ſwims on the ſurface of the ſolution when hot, but ſubſides on cooling. The colour of this ſulphat of tin is yellowiſh brown, which becomes clear on ſtanding. When ſaturated it depoſits, after a while, needled cryſtals of ſulphat of tin. If the ſolution is evaporated almoſt to dryneſs, it becomes on cooling a white ſemi-opake maſs, which is moſtly again ſoluble in water. When ſulphat of tin has been long boiled, a copious white precipitate ſubſides which will not again diſſolve, and conſiſts of the perfect oxyd of tin retaining a ſmall portion of the acid, and is therefore a ſub-ſulphat. The ſupernatant liquor on copious dilution with water yields a further quantity of a ſimilar white precipitate, after which ſcarcely any of the metallic ſalt remains in the ſolution. A ſimilar precipitate takes place in a greater length of time by ſimple expoſure of the ſolution of the ſulphat to the air. It is probable therefore that the only permanently ſoluble ſtate of union between ſulphuric acid and tin is when the metal is at an inferior degree of oxydation, and that theſe precipitations are occaſioned chiefly by an increaſe of oxydation of the metallic ſalt, which is alſo analogous to the habitudes of the other ſalts of this metal. The ſulphuric acid when much diluted has no ſenſible action on tin, but it would probably diſſolve its ſub-oxyd.

The action of nitric acid upon tin is extremely curious. When this acid, highly concentrated, is poured upon tin filings, no action whatever enſues, but on dilution with a little water a moſt violent effervescence immediately follows, more violent than with any other metal, a prodigious eruption of nitrous gas takes place, and the metal is ſpeedily reduced to a bulky white powder, which is the perfect oxyd of tin retaining a ſmall portion of the acid. When the action of the acid is over, and the mixture has been diluted with water, and allowed to clear by ſubſidence, the ſupernatant liquor is moderately acidulous, but contains ſcarcely a particle of metal in ſolution, ſo that it may be ſaturated with an alkali with very little change of its tranſparency[f]; but on evaporation nearly to dryneſs it depoſits in the form of a white oxyd what little of the metal it ſtill retained. Tin may however be diſſolved in nitric acid, if it be conſiderably diluted, without exciting any effervescence. In this ſtate, when the metal is immerſed in the acid it gradually falls to pieces in the form of a black powder,[d] which is quietly diſſolved in the acid till the whole diſappears, or till the acid is ſaturated. Some heat is given out in the proceſs, which ſhould be checked by putting the veſſel in cold water; and to make a ſaturated ſolution, the tin ſhould only be added in ſmall quantity at a time.

This ſolution is yellow, and in a day or two it depoſits ſpontaneouſly part of its metal in the form of an oxyd, or immediately, if at all heated. Both the ſolution and the oxyd however contain the metal in the lower ſtate of oxydation, for both the former, and the latter, when rediſſolved in muriatic acid, precipitate corroſive muriat of mercury black. If nitric acid is added to the ſolution, and heat applied, a copious effervescence ariſes, and the whole of the tin ſeparates as white or perfect oxyd. The union between nitric acid and oxyd of tin therefore is very weak and little permanent, and only exiſts when the metal is in the ſtate of ſub-oxyd.

Whenever tin is diſſolved or oxydated by nitric acid ammonia is generated, and in very ſenſible quantity. The production of this alkali is rendered very apparent in the following way. Moiſten a few drachms of tin filings with nitric acid ſomewhat diluted, and in the midſt of the effervescence excited thereby add a quantity of quicklime in powder, when on rubbing them together a very pungent ſmell of volatile alkali will be perceived. In this caſe the ammonia which is formed, firſt unites with part of the nitric acid, but is again expelled from it by the lime, and being volatilized is made obvious to the ſmell. The production of ammonia implies a very complicated action. As this alkali is not contained, as ſuch, in the nitric acid, the water, or the tin, it muſt be produced by the inſtantaneous combination of its elements, azot and hydrogen, during the mutual action of theſe three bodies.

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[e] Baumé.

[f] Prouſt J. Phyſ. tom. 51.

Of theſe the nitric acid alone can furniſh the azot, and the water, the hydrogen; conſequently a portion of nitric acid muſt be totally decompoſed into its ultimate conſtituents, azot and oxygen; and a correſponding portion of the water muſt be equally reſolved into hydrogen and oxygen. This double decompoſition therefore, and the union of the azot of the one with the hydrogen of the other to form ammonia, muſt leave a diſpoſable quantity of oxygen from each, which, as it does not fly off in the form of gas, muſt be fixed by ſome of the ſubſtances preſent, which is doubtleſs the metal in this inſtance, as it is oxygenated to the higheſt poſſible degree, and contains a large quantity of this principle. A great proportion of the oxygen is alſo furniſhed by the direct decompoſition of the nitric acid, by means of the metal, as is proved by the copious production of nitrous gas, and alſo of *nitrous-oxyd*, as has been mentioned under that article. The quantity of ammonia generated has been eſtimated by an experiment of Guyton.[g] He heated, in a retort, two parts of nitric acid with three of tin, diluting the acid largely with water. Though there was a very marked action between the acid and metal, no gas was given out, but the reſidue contained nitrat of ammonia, of which the ammonia amounted to nearly the twentieth part of the joint weight of the acid and the tin employed.

The white perfect oxyd, produced by the utmoſt action of nitric acid on tin, is compoſed, according to Prouſt, of about 28 per cent. of oxygen and 72 of tin; 100 parts of the metal receiving an increaſe of 40 by the oxygenation.[h]

Tin diſſolves copiouſly and with eaſe in muriatic acid. The ſolution goes on even in the cold, but with much more rapidity when warmed. The muriatic acid immediately loſes its yellow colour, a gentle effervescence ariſes, and a quantity of hydrogen is given out, which has a very peculiar and offenſive ſmell, which has been compared to that of old privies. This has been thought by ſome to depend on the ſolution in the hydrogen of a little of the arſenic which moſt tin contains, forming that peculiar modification of this gas which has been already deſcribed under the article *Arſenicated Hydrogen*. However, though it is certain that when arſenic is preſent ſome of it may be volatilized by the hydrogen, it does not appear very probable that this is the ſole cauſe of this very peculiar ſmell of the hydrogen from tin, ſince the pureſt poſſible tin gives the ſame gas, and therefore we ſhould rather conſider it as owing to the volatilization of a minute quantity of the tin itſelf.

The moſt concentrated muriatic acid will diſſolve, in a boiling heat, more than a quarter of its weight of tin, and a blackiſh-grey inſoluble powder is left behind, which has not been examined. The ſolution contains an exceſs of acid, however highly it is ſaturated with metal, which exceſs is eſſential to this muriat when ſoluble in water. It is perfectly limpid and colourleſs as water, has a ſtrong ſtyptic and metallic taſte, and contains the metal in the loweſt ſtate of oxydation. It is therefore properly a *muriated ſub-oxyd* of tin; and we ſhall at preſent give it this term, to diſtinguiſh it from another muriat in which the tin is in a high ſtate of oxydation, and which we may term *muriated ſuper-oxyd*.

Each of theſe ſalts has very remarkable and diſtinguiſhing properties.

The hot-ſaturated ſolution of muriated ſub-oxyd depoſits, on cooling, an abundance of cryſtals of the ſalt, which are generally in the form either of ſmall ſcales, or of long acicular priſms. A further quantity may be obtained by evaporation. Theſe cryſtals when rediſſolved and evaporated again (retaining a ſlight exceſs of acid) may be obtained larger and more regular, but by expoſure to air the nature of the ſalt is gradually changed by the abſorption of oxygen. The union of the oxyd of tin, in either ſtate, with muriatic acid, is much more permanent than with the nitric or ſulphuric acid, ſo that the ſolution, when ſlightly acidulous, may be repeatedly heated and cooled without depoſiting its oxyd.

The muriated ſub-oxyd of tin is diſtinguiſhed by its poſſeſſing an extreme affinity for oxygen, greater than that of any other metallic ſolution; in conſequence of which it deprives of oxygen (partially or totally) all the metallic ſalts, and many other bodies, which gives riſe to an infinite number of curious experiments, the knowledge and true explanation of which is due chiefly to the ingenious labours of Pelletier and Prouſt.

The following are ſome of the examples of deoxygenation produced by this muriat; but it ſhould be premiſed, that as the ſolution abſorbs oxygen even from the atmoſphere, it ſhould be kept in a well-cloſed bottle, and the low degree of oxygenation will be ſtill further inſured by keeping ſome bits of metallic tin immerſed in it.

This ſolution does not affect the ſulphuric acid; but when added to the ſulphureous acid, a conſiderable heat is excited in a few minutes, and a yellow ſulphuretted oxyd of tin is precipitated.

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[g] Encycl. Method Art. Etain.

[h] J. Phys. tom. 51.

Concentrated nitrous acid, added to the ſolution of tin, cauſes an immediate extrication of nitrous gas, ſo copious as to be almoſt exploſive, and the ſolution is compleatly oxygenated.

Oxymuriatic acid is inſtantly deprived of its peculiar pungent ſmell, by adding a few drops of the ſolution, and the oxygen of the acid unites with the tin.

White arſenic, and the arſenic acid, digeſted with the ſolution, are both decompoſed, and a black powder is precipitated, which is arſenic in the metallic ſtate.

The red oxyd of mercury is decompoſed immediately by the ſolution, and corroſive muriat, by gentle heating; and in both caſes the metal is totally reduced into globules of running mercury.

The white oxyds of antimony and zinc are reduced by the ſolution, and aſſume the metallic form.

The ſolutions of ſilver undergo a ſimilar change.

The nitro-muriat of gold, added to this ſolution, cauſes that purple precipitate deſcribed under the article Gold, and called, after the inventor, Caſſius's precipitate.

The ſolutions of highly-oxygenated iron, ſuch as the red ſulphat, are immediately brought by this muriat of tin to that ſtate in which the metal is in the loweſt degree of oxygenation, which is the reaſon why the common yellow muriatic acid, that owes its colour to iron, is rendered colourleſs as ſoon as tin is immerſed in it. The ſolutions of copper undergo a ſimilar change.

Theſe phenomena have been already deſcribed fully, under the articles *Copper*, *Iron*, and *Pruſſic acid*.

Hydro-ſulphuret of potaſh gives a black precipitate with this muriat of tin.

Laſtly, when a little of this muriat is confined with oxygen gas or common air, it acts like the common eudiometrical ſubſtances, and gradually abſorbs oxygen.

This muriat, when heated *per ſe* in a retort, firſt gives out water and acid, which carry up a ſmall quantity of tin, after which the remaining muriat quietly fuſes in the retort, without further change, till the heat is raiſed to low redneſs; but it then ſublimes almoſt entirely, and concretes in the neck of the retort in a ſolid form, leaving only a ſmall quantity of a white oxyd behind, which becomes fixed, owing to a deficiency of acid.

The ſublimed muriat does not appear to be changed by this proceſs, except by the loſs of part of its acid, for by the addition of a little freſh muriatic acid, it totally diſſolves, and, as before, gives a black precipitate with corroſive muriat of mercury; ſo that it ſtill remains in a low degree of oxygenation. On the other hand, the muriated *ſuper-oxyd* is volatile at a very gentle heat, as we ſhall preſently mention; ſo that diſtillation furniſhes a ready method of ſeparating theſe two muriats, the ſuper-oxydated ſalt riſing entirely at a much leſs degree of heat than that at which the ſub-oxydated ſalt acquires any volatility.[i]

When the cryſtals of the muriated ſub-oxyd are diſſolved in a good deal of water, the ſolution ſoon becomes milky, and a conſiderable precipitate is formed.[k] This precipitate is ſoluble with eaſe in muriatic acid, and this ſolution gives, as at firſt, a black precipitate, with corroſive muriat of mercury, and with hydro-ſulphuret of potaſh; conſequently the degree of oxygenation is not altered. It alſo diſſolves in nitric acid, and the ſolution depoſits luna cornea with nitrat of ſilver, and conſequently contains muriatic acid. By diſtillation, in open fire, it gives ſome vapour of muriat of tin, and afterwards muriatic acid, and a grey oxyd is left behind. This precipitate, therefore, is the muriat with exceſs of oxyd, or (what amounts to the ſame) the oxyd with deficiency of muriatic acid; and would be accurately termed a *ſub-muriated ſub-oxyd*; and, on the other hand, the ſupernatant liquor contains the metallic ſalt with an exceſs of acid, ſo as to redden litmus. Here, therefore, as in many ſimilar inſtances, (ſuch as that of the ſulphat of mercury and turbith) the dilution of the ſalt with much water cauſes an unequal ſeparation of its conſtituent parts, the inſoluble portion containing much oxyd and little acid, and the ſoluble portion, the reverſe. By adding muriatic acid, all the precipitate diſappears, and the whole becomes an uniform ſolution, with exceſs of acid. In all theſe changes the degree of oxydation is not apparently changed.

The action of the alkalies and alkaline earths on the ſolution of muriated ſub-oxyd of tin, is curious and complicated. If a few drops of cauſtic potaſh, for example, are added to this ſolution, a white precipitate takes place, which, however, is not a pure oxyd of tin, as might be ſuppoſed, but a *ſub-muriat*, preciſely the ſame as the ſalt produced by adding much water to the cryſtallized muriat. The ſupernatant liquor *is ſtill acidulous*, ſo that the firſt effect of the alkali is not to ſaturate the whole exceſs of acid, but to abſtract the greater part of the acid from that portion only of the muriat which is precipitated as a ſub-muriat. This action of the alkali continues to the laſt, ſo that as long as a particle of muriat of tin remains in ſolution, it remains acidulous. If the addition of potaſh is continued after all the metal is precipitated from the ſolution as a ſub-muriat, (no artificial heat being uſed) this precipitate gradually diſappears, and a triple combination of muriatic acid, potaſh, and ſub-oxyd of tin, is formed, which is partly cryſtallizable in rhomboidal priſms. The triple ſalt, produced in a ſimilar manner, by ammonia and by barytes, aſſumes the ſame form; when by ſoda or ſtrontian, the form is that of fine needles; the muriat of tin and lime is deliqueſcent. If, however, the precipitated ſub-muriat is digeſted with an alkali, and *heat applied*, the acid is totally ſeparated from the oxyd, and the latter is either re-diſſolved in the alkali, or, if but little alkali be uſed, moſt of it remains at the bottom in the form of a pure grey ſub-oxyd, in which the proportion of oxygen is only about 22 per cent. whereas the ſuper-oxyd formed by nitric acid and tin, and deprived of its ſmall retent of acid in the ſame way, contains about 28 per cent. of oxygen.

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[i] Prouſt.

[k] Berthollet Chemical Statics, (Note to vol. ii.)

The carbonats of potaſh and ſoda precipitate the ſolution of muriat of tin with a briſk effervescence. The precipitate is not however a carbonat of tin, but a ſub-muriat, as with the pure alkalies, and an exceſs of the carbonat in the ſame manner, re-diſſolves the precipitate.

Another change, however, takes place, when the alkalies are digeſted with the oxyds of tin. The alkalies diſſolve both theſe oxyds, but their affinity with the ſuper-oxyd is much greater than with the ſub-oxyd; whence it happens, that if a clear ſolution of the ſub-oxyd in cauſtic potaſh be kept in a perfectly cloſed veſſel, at the end of ten or twelve days a ſingular cauliflower-ſhaped depoſit is formed, which Prouſt conſiders as reguline tin, but which appears rather to be tin in an extremely low ſtate of oxydation, as it is ſoluble in cold muriatic acid, without giving out hydrogen.[1] The ſupernatant alkaline liquor, on the other hand, now contains the metal in the higheſt ſtate of oxydation; for when ſeparated from the alkali by muriatic acid, and re-diſſolved in the ſame menſtruum, it gives no precipitate whatever to the ſolution of corroſive mercurial muriat, which is a teſt of the ſuper-oxydated ſolutions.

In this caſe an unequal diviſion both of the metal and oxygen takes place; one part of the metal, into which the greater part (if not all) of the oxygen is condenſed, forms a permanent union with the alkali, and the remainder of the metal falls down nearly in the reguline ſtate, and ſymmetrically arranged. This change takes place more ſpeedily, by boiling a ſolution of potaſh on a greater quantity of the oxyd precipitated from a muriat than it is capable of diſſolving.

We proceed to the Super-oxydated Muriat. This ſalt was long partially known, before its true nature was explained, as it conſtitutes, when concentrated by diſtillation, that ſingular ſmoking compound firſt diſcovered by Libavius, which on that account was termed *Smoking Liquor of Libavius*. It is prepared in the following way: melt, in an iron ladle, 5 oz. of pure tin, add to it 5 drams of mercury, ſtir them together, and pour out the amalgam into a marble mortar, into which put 20 oz. of corroſive mercurial muriat in fine powder, and mix the whole thoroughly. Put the whole of the mixture into a glaſs retort, with a receiver, not quite cloſely luted, and apply a moderate heat, with an Argand lamp or a ſand bath. At firſt, about 5 oz. of a colourleſs liquid diſtills over quietly, after which there riſes, quite ſuddenly and with a moderate exploſion, a great quantity of white heavy vapour, which condenſes into a tranſparent liquid, and mixes with that which has firſt paſſed. This is to be quickly poured into a well-ſtoppered glaſs phial, and is the *Smoking Muriat of Tin*, or *Liquor of Libavius*. The uſe of the mercury, in amalgamating the tin, is merely for the convenience of dividing it, as the filings of tin alone, with the corroſive muriat, will anſwer the ſame purpoſe.

Prouſt gives, as the beſt proportions, 8 oz. of *powder* of tin, (probably ſuch as is made by melting the metal, and ſhaking it in a box) and 24 oz. of corroſive ſublimate, which affords 9 oz. of the ſmoking liquor.

If the receiver be changed after the ſmoking liquor has come over, and the heat be very much increaſed, a ſolid *butter of tin* firſt ſublimes, which appears to be the muriated ſub-oxyd, mixed with globules of mercury, when the amalgam has been originally employed. Together with this muriat there riſes a quantity of calomel ariſing from the partial decompoſition of the corroſive muriat, and if the heat has been kept at redneſs for a ſufficient time, all the muriated ſub-oxyd of tin, calomel, and running mercury, will be ſublimed, and only a grey powder left, which is probably chiefly a ſub-oxyd of tin.

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[1] Berthollet.

The ſmoking muriat when incloſed in a bottle preſents nothing remarkable, but the empty part of the bottle above the level of the liquid ſoon becomes lined with cryſtalline needles, which generally cauſe the ſtopper to adhere to a very troubleſome degree. When this liquor is expoſed to the air it immediately ſends forth a quantity of denſe white vapours which excite coughing, and condenſe into a ſemi-cryſtallized pellicle on the contiguous ſurfaces. The preciſe nature of this ſingular liquid has been illuſtrated by a very ingenious ſeries of experiments by M. Adet,[m] and afterwards by M. Pelletier.[n]

From thoſe of the former chemiſt we have the following facts: when a little of this liquor is poured into a cup, and encloſed under a bell-glaſs *over water*, the whole of it evaporates in white fumes, which preſently cryſtallize on the ſides of the glaſs in the form of a ſaline vegetation. Theſe cryſtals have now loſt the property of ſmoking, are ſomewhat deliqueſcent, and readily diſſolve in water into an acid ſolution of muriat of tin. This cryſtallized condenſation of the vapour is owing to its union with the moiſture held in ſolution in the air, and which is conſtantly ſupplied by the water over which the veſſel ſtands, ſo that in fact this ſubſtance is a moſt powerful hygrometer. In proof of which M. Adet found, that when the fuming muriat was confined with a ſmall quantity of *dry air*, ſcarcely any of the cryſtalline vegetation was depoſited, but it immediately appeared when the air from the lungs was introduced, which is known to be loaded with moiſture. The ſmoking muriat therefore loſes its ſmoking property, and ſolidifies by union with a certain quantity of water, and is again reducible to a liquid by a greater proportion of water. This may alſo be ſhewn more directly; when the muriat is mixed with not more than about a third of its weight of water, much heat is given out, and the whole ſuddenly congeals, at a common temperature. At the ſame time a number of bubbles of gas, apparently pretty pure azot, are given out, the cauſe of which is not very obvious, but it ſeems to bear an analogy with the expulſion of air from water, and all other liquids in the act of freezing; and both in this circumſtance, as well as in the evolution of caloric, the fixation of the water may be conſidered as equivalent to congelation. This ſolid maſs readily liquefies in a gentle warmth, and by the addition of more water it is reſolved into a mere ſolution of the ſuperoxydated muriat of tin without giving out any more vapours.

The habitudes of this muriat with reguline tin throw much light upon its true nature. If this muriat, diluted with ſo much water as to become ſolid when cold, is liquefied by heat and digeſted with ſome filings of tin, a conſiderable portion of the freſh metal is diſſolved, *without the diſengagement of hydrogen* or any gas whatever, and when ſaturated, the ſolution has now loſt all the characteriſtic properties of the ſmoking muriat, will bear being heated to redneſs with very little loſs by ſublimation, and then concretes into a brown maſs which cloſely reſembles the common fuſed *muriated ſub-oxyd.* This ſtriking experiment ſhews, in the firſt place, that the tin in the ſmoking muriat is in a high ſtate of oxydation, ſo that it can impart a portion of oxygen to an additional quantity of metal ſufficient for its ſolution; for as no hydrogen is given out, the oxygenation of the freſh portion of metal cannot (as in the common ſolution in the muriatic acid) ariſe from the decompoſition of water. It alſo ſhews that tin in a low ſtate of oxydation requires much leſs muriatic acid for its ſolution than in the higher ſtate, (and conſequently that its affinity for the acid is ſtronger) otherwiſe the tin laſt added, though oxydated, could not be held in ſolution, as it is, and with that ſenſible exceſs of acid which, as we have already mentioned, is eſſential to a ſolution of the muriated ſub-oxyd.

Pelletier in his experiments on muriat of tin (many of which have been already related) endeavoured to form the ſmoking muriat by compleatly oxygenating the common ſolution of tin in muriatic acid. This he effected by paſſing oxymuriatic gas through this ſolution, which abſorbs it readily, 2400 grs. of tin diſſolved in four times its weight of common muriatic acid taking up 2 oz. of the gas. This liquid, boiled for a few minutes to expel a little uncombined gas which it contained, yielded a clear limpid ſolution, free from the peculiar pungent ſmell of oxymuriatic acid, in which the metal is certainly as highly oxygenated as poſſible. When this ſolution was evaporated conſiderably it depoſited cryſtals exactly reſembling thoſe afforded by the ſmoking muriat when a little diluted with water, and by further evaporation a ſolid ſalt was obtained, which, like the ſmoking muriat ſublimed totally in a moderate heat. It does not appear whether this accurate chemiſt made any further trials to aſcertain the identity of the two ſolutions, but they appear to reſemble each other in every property, but that of fuming, which could not be given to the ſolution prepared by oxymuriatic acid gas. It is probable, however, that this property only depends on the extreme concentration of the muriat prepared by diſtilling tin and *dry* corroſive muriat of mercury, for M. Adet alſo found, that on adding water to theſe materials before diſtillation, the diſtilled liquor was not fuming, but reſembled the fuming muriat after dilution.

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[m] An. Chim. tom. I.

[n] Memoires de Pelletier, tom. I.

This muriat gives no precipitate with the ſolution of gold, but only changes the colour to a clear claret red. It is decompoſed by the alkalies, partially when cold and entirely when heated ; but the oxyd of this ſalt is more readily ſoluble in an exceſs of alkali than the ſub-oxyd of the other muriat.

It may be uſeful to recapitulate in a few words the characteriſtic properties of the two muriats.

The *ſub-oxydated muriat* is made ſimply by diſſolving tin in muriatic acid ; it gives no fumes on expoſure to air—gives a black precipitate with hydroſulphuret of potaſh—has a very ſtrong affinity for oxygen, and in conſequence gives a black precipitate with corroſive ſublimate, which is converted by heat into running mercury; gives a red purple precipitate with nitro-muriat of gold, and diminiſhes the ſtate of oxydation of all other metallic ſolutions—abſorbs oxygen from the air, and oxymuriatic acid gas when paſſed through it, and deſtroys the peculiar ſmell of the latter ſubſtance—is cryſtallizable—requires a low red heat for its ſublimation.

The *ſuper-oxydated muriat* is made either by diſſolving the perfect oxyd in muriatic acid, or by ſaturating the former muriat with oxymuriatic gas, or by diſtilling dry corroſive ſublimate of mercury and tin, in which laſt caſe it is volatile in the atmoſphere in denſe fumes, which cryſtallize by abſorbing moiſture; it gives a yellow precipitate with hydroſulphuret of potaſh, and no precipitate at all with nitro-muriat of gold, or with a ſolution of corroſive muriat of mercury—it diſſolves a freſh quantity of metallic tin without the production of hydrogen, and then is changed to the ſub-oxydated ſalt—it has no further affinity for oxygen (being ſaturated with this principle)—and it is totally volatilized in diſtillation at a very gentle heat.

Muriatic acid appears to have a ſtronger affinity for the ſub-oxyd of tin than for the ſuper-oxyd, for the ſolution of the latter oxyd gradually depoſits a quantity of its oxyd by keeping, which the ſolution of the former does not readily do unleſs much diluted with water, or unleſs it is kept in a bottle looſely ſtopped, which allows it to abſorb oxygen from the air.

On the other hand, the alkalies have much the ſtrongeſt affinity for the moſt highly oxydated tin.

The nitro-muriatic acid diſſolves tin copiouſly and with great eaſe, and is the acid commonly employed for the ſolution of this metal in the large way for the uſe of the dyers, with cochineal colours. A mixture of two or three parts of muriatic acid and one of nitric, forms the beſt proportions for this compound acid. A violent effervеſcence is excited when the tin is immerſed, and much heat is generated, which if too great, would cauſe moſt of the metal to ſeparate in the form of a white inſoluble oxyd, ſo that the vehemence of action ſhould be checked by ſetting the veſſel in cold water, and adding the tin by very ſmall portions at a time. In this way the concentrated nitro-muriatic acid will hold in ſolution about half its weight of tin, but if the acid is not previouſly a good deal diluted, it congeals, when cold and ſaturated with metal, into a tremulous gelatinous maſs, generally ſomewhat opaleſcent and ſemi-opake, which by keeping, hardens conſiderably. The addition of a ſmall quantity of water only increaſes its ſolidity, but a greater quantity reſtores its liquidity, with the depoſition however of a part of its metallic contents, as an inſoluble oxyd. When this ſolution is heated a new effervеſcence is excited, and if not too dilute, it hardens into a tranſparent gelly on cooling.

The ſolution actually made by the ſcarlet dyers,[*] and called by them *Spirit*, is prepared with that ſpecies of dilute nitric acid, termed *ſingle aqua fortis*, to every pound of which are added from one to two ounces of common ſalt or ſal-ammoniac. The acid thus prepared will diſſolve about an eighth of its weight of tin, which is previouſly granulated by being poured, when melted, into water briſkly agitated by rods. This acid is ſtill further diluted, and the heat of ſolution is checked by ſetting it in cold water, and adding the metal very gradually. The proceſs of ſolution is thus protracted to two or three days.

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[*] Bancroft on Colours.

The ſtate of oxydation of the metal in this ſolution muſt vary, but when it is recent, and has been made very gradually, and without heat, the tin muſt be in low oxydation, which is the ſtate probably the moſt deſirable for the dyer, as the acid is more ſaturated and leſs liable to depoſit oxyd by keeping.

When tin filings are thrown into oxymuriatic gas they take fire and burn with a bluiſh-white flame. The reſidue is partly ſoluble in water.

The liquid oxymuriatic acid diſſolves this metal quietly without efferveſcence. The reſult is a muriat of tin more or leſs oxydated according to the quantity of acid employed.

Moſt of the vegetable acids act upon tin.

Vinegar, either common or diſtilled, when digeſted with tin filings, particularly with the aſſiſtance of heat, aſſumes a whitiſh opaleſcent colour, a diſagreeable ſmell and metallic taſte, gives a yellowiſh white precipitate with hydroſulphuret of potaſh, and a deep purple precipitate with nitro-muriat of gold. It therefore holds the tin which it has diſſolved, in a low ſtate of oxydation. This ſolution readily depoſits moſt of its metallic contents as an inſoluble oxyd, when by expoſure to air it has abſorbed an additional quantity of oxygen. If the recent ſolution is ſlowly evaporated till it begins to ſhew a ſaline cruſt, and is then ſuffered to remain undiſturbed in a cool place for a day or two, it depoſits groups of needle-formed cryſtals of acetite of tin.

The acetic acid, being more concentrated than common vinegar, diſſolves tin more readily and in ſomewhat larger quantity, but even with this acid the quantity diſſolved is very ſmall.

The ſub-oxyd of tin produced by ſaturating the common muriat by a carbonated alkali, alſo diſſolves in vinegar, but the perfect oxyd is inſoluble in this as in moſt other acids.

Carbonated water added to a ſolution of acetited tin cauſes a white powder to precipitate, which is probably a carbonated ſub-oxyd.

A very concentrated acetite of tin is made[p] by adding a ſaturated ſolution of cryſtallized muriat of tin to acetited lead. A double decompoſition takes place, muriat of lead is precipitated, and the ſupernatant liquor is chiefly a ſtrong acetite of tin. This is ſtrongly recommended by the inventor as a mordant for a variety of dyeing proceſſes.

Tin is ſoluble in the acid of tartar, and this ſolution is of importance in manufacture, as it is the method by which *wet tinning* is performed on copper and braſs. Pins are whitened in this manner, but by a compound menſtruum.

This proceſs is eaſily performed: a ſolution of about one part of cream of tartar, two parts of alum, and as much common ſalt, is made in a moderate quantity of water, and tin filings or granulated tin is thrown in, and the liquor boiled. The pins, which are made of braſs wire and perfectly bright, are then put in, and after remaining in the boiling liquor for a time, they are compleatly covered with a beautiful white uniform coating of tin, which is the ſtate in which they are uſed.

It is not neceſſary to employ this mixture of ſalts for the mere tinning of copper or braſs. Either of theſe three ſalts ſingly with tin filings will anſwer the purpoſe, but cream of tartar gives a duller and more leaden-looking tinning, and alum on the other hand gives a very fine ſilver white but without gloſs, ſo that the mixture above-mentioned is found to produce the moſt deſirable hue.

In a chemical point of view this operation is curious, and appears to preſent a contradiction to the uſual laws of affinity, for when tin is immerſed in a common ſolution of copper, it precipitates moſt of the copper in the metallic ſtate.

The circumſtances requiſite to produce a precipitate of metallic tin on copper, have been examined in an able ſet of experiments by Prof. Gadolin, a Swediſh chemiſt, an account of which is inſerted in the Stockholm Tranſactions for 1788, to which are added ſome other experiments and remarks by Baron de Gedda.[q] It is to be obſerved, that the circumſtances relating to the oxygenation of metals in their ſolutions in acids were very incompleatly known at that time, ſo that we may now account for phenomena which muſt have been inexplicable at that period. The facts however cannot vary, and are always valuable. This chemiſt chiefly confined himſelf to the action of a ſingle ſalt, namely tartar, or its acid. We ſhall ſelect and give in a few words ſome of the experiments.

1. Tartrite of potaſh was added to nitro-muriat of tin, which cauſed a white precipitate of tartrite of tin, which was edulcorated and dried. Some of this precipitate was boiled with water, and copper was immerſed; but the copper was in no degree altered.

2. Some of the above tartrite of tin was acidulated with tartareous acid and copper was boiled in it, but with no effect.

3. Some of the ſame tartrite of tin was treated

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[p] Hauſſman.

[q] Journ. de Phyſ. tom. 34, p. 362 & 430.

treated as in the laſt experiment, but with the addition of ſome leaf-tin and the copper was now compleatly tinned.

4. The laſt experiment was repeated, but without an exceſs of acid, and no effect was produced on the copper.

5. Cream of tartar, tin filings, and a piece of copper, were boiled together, and the copper was compleatly tinned.

Theſe experiments ſhew that in order to precipitate tin upon copper by means of tartar, it is neceſſary, both that ſome metallic tin ſhould be preſent in the ſolution, and that the ſolution ſhould contain an exceſs of acid.

6. Some oxyd of copper ariſing from the decompoſition of blue vitriol by an alkali, was firſt boiled in a ſolution of cream of tartar, after which both tin-leaf and copper were introduced, and the whole boiled together for three hours. Both the copper and tin were covered with a cruſt of blackiſh metallic alloy.

7. Some copper was tinned by boiling with tin and a ſolution of tartar. The liquor after the copper was withdrawn was not changed to blue by volatile alkali, and hence was inferred to contain no copper, though when expoſed to the light ſome faint blue ſtreaks were obſervable.

8. The ſame experiment was repeated with tartar, alum, and ſalt, (the uſual mode of tinning) and no indications of copper were furniſhed by the volatile alkali.

9. Copper was tinned with each of the above three ſalts ſingly, and in neither inſtance did the volatile alkali give any indications of diſſolved copper in the liquor.

10. Tin-leaf was boiled for an hour with a ſolution of cream of tartar. The tin was then withdrawn and a bar of iron introduced, and the boiling continued. The iron was ſoon blackened at its ſurface, and after three quarters of an hour, was covered with a mixture of reduced metallic tin and oxyd of tin, and the iron had loſt weight in the proceſs.

Hence as iron was found to precipitate tin in a metallic ſtate from its ſolution, it was conjectured that iron added to a ſolution of tin, in which copper was immerſed, might determine the tinning of the copper. The experiment however ſucceeded but imperfectly when tartar was uſed, owing to the languor of its action on iron, and even when a few drops of ſulphuric acid were added, the tin was precipitated ſolely on the iron, whilſt the ſurface of the copper remained unaltered, but with alum it was different.

11. Some tin-leaf was boiled with a ſolution of alum for half an hour and then withdrawn. Into the ſolution were then introduced a piece of poliſhed copper, and ſome iron filings. The latter were acted on with much rapidity, and in a few minutes the copper was covered with a pellicle of tin, which in half an hour gave it the appearance of fine ſilver unpoliſhed.

12. Tin-leaf and a ſolution of alum were boiled together. The tin was then taken out, and into the ſolution both iron and copper were introduced, each poliſhed. After a few minutes boiling both theſe metals were highly tinned.

13. Some ſulphat of copper was diſſolved in water, tin leaf was added, and the mixture was expoſed to a moderate heat for ſome days in a well cloſed phial. In a few days the colour of the ſolution entirely diſappeared, and the copper precipitated to the bottom of the veſſel. The clear ſupernatant fluid was diſtributed into three phials, into the firſt of which was put copper and tin; into the ſecond, copper and iron; and into the third, copper alone. They were well corked, and after digeſtion in moderate heat for ſome hours the copper in the firſt phial, and the copper and iron in the ſecond were well tinned, but the copper in the third remained unaltered.

From the above experiments we may clearly make out that the ſtate of the ſolution of tin, when it is diſpoſed to precipitate in a metallic form on the ſurface of copper immerſed in it, is that of the loweſt degree of oxydation, which is obtained either by keeping ſome undiſſolved tin in the ſolution or (Exp. 10 and 11) by introducing iron. The great difficulty which occurred to the author of theſe experiments was to account for the precipitation of the tin when there did not appear to be any copper diſſolved during the proceſs, for in all other metallic precipitations (as that of copper on iron for example) the ſeparation of one metal from the ſolution is attended with the ſolution of a correſponding quantity of the other metal.

The difficulty is increaſed too by the fact that when tin is immerſed in a ſolution of copper the copper is precipitated, and a portion of the tin is diſſolved, ſo that the direct affinity of acids for tin is greater than for copper.

The hypotheſis given by Prof. Gadolin to explain this is highly ingenious. He obſerves that as a very ſtrong affinity exiſts between tin and copper, this affinity operates on the metallic part of the ſolution of the tin immediately in contact with the copper, and cauſes its ſeparation in the metallic form, whilſt the remainder of the tin, which is the greateſt portion, undergoes a greater degree of calcination (i. e. oxygenation) and hence too the ſolution after its utmoſt action on copper ſtill retains a quantity of tin. In other words, the diſſolved tin divides itſelf into two portions, one of which returns to the metallic ſtate, and adheres to the copper, whilſt the whole of the oxygen condenſes in the other portion, which remains diſſolved.

To ſhew that a correſponding ſolution of the *precipitant* (i. e. the copper) is not neceſſary to the ſeparation of the *precipitate*, M. Gadolin boiled ſome fine gold with tin and tartar, and after a ſhort time the gold was compleatly covered with a coating of reduced tin, and it cannot be ſuppoſed that any of the gold ſhould have been diſſolved by the tartar. This experiment would have been more compleat if the tin had been again ſeparated from the gold by muriatic acid, and the gold had been weighed before and after the operation, but if this ſtatement is accurate (which there is no apparent reaſon to doubt) it is a curious fact, and one for which in addition to M. Gadolin's explanation, we muſt probably refer to the late diſcovered experiments in Galvaniſm. This is confirmed by the circumſtance that in every one of the experiments on tinning above related, the preſence of two diſſimilar metals in the reguline ſtate is required, ſo that the moment the metallic tin is withdrawn from the tartareous ſolution the precipitation of tin upon copper ceaſes, though we can hardly ſuppoſe that any immediate change in the ſtate of oxygenation of the ſolution takes place.

With reſpect to the circumſtance of no copper being found in the ſolution of tartar after common tinning, we may obſerve however that the failure of the uſual teſt of the volatile alkali is no certain proof of the abſence of this metal in this inſtance, as the later diſcoveries of Prouſt on this ſubject (which are detailed under the article *Copper*) ſhew that when copper is in ſolution with tin in a low ſtate of oxydation, it is ſo far deprived of oxygen by the tin, as not to turn blue with ammonia.

The experiments in which iron, copper, and tin were immerſed into a ſolution of tin, are complicated, and the exact operation of all the affinities between the reſpective ſubſtances is not eaſily made out. The order of precipitation with a ſingle metal, and a ſingle metallic ſolution, is copper, tin, iron; that is to ſay, iron immerſed into a ſolution of tin diſplaces the tin, and precipitates it moſtly in the metallic form; and tin immerſed into a ſolution of copper precipitates the latter metal. But in the above complicated caſe both the iron and copper become tinned, ſo that the tinning of the iron may be effected by ſimple and direct affinity, but that of the copper requires a complicated action, to which probably the metallic tin preſent contributes.

When cream of tartar has been long boiled with tin till it can diſſolve no more, the ſolution ſtill remains acidulous, and when evaporated and cryſtallized a triple ſalt is obtained, compoſed of tartareous acid, potaſh, and oxyd of tin, which may be termed a *ſuper-tartrite of potaſh with tin*.

The fixed alkalies have ſome action upon metallic tin, tarniſhing its ſurface and diſſolving a ſmall portion though with difficulty. But on the oxyds of this metal alkali acts with great energy, diſſolving them copiouſly and with eaſe. The circumſtances of ſolution and precipitation of the oxyd from the acid ſalts by potaſh, have been already mentioned. Potaſh appears to have a ſtronger affinity for the perfect oxyd than the ſub-oxyd, ſo that in a mixture of the two it diſſolves the former in preference. This ſolution does not readily depoſit its oxyd by keeping, or by expoſure to air, as the ſolutions of the ſame oxyd in acids do, but may be cryſtallized by gradual evaporation.

The effect of alkalies in breaking the aggregation of the native oxyd, and thus rendering it ſoluble in acids, has been mentioned in the analyſis of the ores.

Muriat of ammonia acts upon tin by the aſſiſtance of heat. When this ſalt and tin filings are heated in a retort, a ſmall quantity of hydrogen gas is firſt given out,[r] and if the heat be continued, for a time, below redneſs, a ſaline maſs is formed, compoſed of muriated ammonia, muriat of tin, and ſome tin filings unchanged. The muriat of tin contains the metal in the ſtate of ſub-oxyd, as it gives a purple precipitate with ſolution of gold, and a black one with hydro-ſulphuretted water.

Tin unites readily with ſulphur by fuſion. For this purpoſe melt ſome tin in a crucible, heat it ſhort of redneſs, throw upon it about a third or a fourth of its weight of ſulphur, and ſtir them together when melted. The mixture inflames when heated to a certain degree, and ſhould then be covered. When this has ſubſided remove the crucible, and black brittle ſul-

[r] Prouſt.

phuret of tin is obtained. To ſaturate the tin with ſulphur the heat ſhould be moderate, and the projection of ſulphur repeated once or twice, till the tin appears to be ſaturated.

The quantity of ſulphur retained by the tin in this proceſs is variouſly given, and no doubt actually varies. Mr. Woulfe[s] found 4 oz. of tin to furniſh 5 oz. of the ſulphuret, and even then it is not entirely ſaturated, for on rubbing it in a mortar a portion remains which extends under the peſtle, and therefore is ſtill malleable and unſaturated with ſulphur.

On the other hand, Bergman finds that 100 parts of tin will take up in this way no more than 20 of ſulphur, in which proportions Prouſt agrees. But Pelletier[t] found the increaſe on 100 of tin to be no more than 16½ of ſulphur, ſo that the ſaturating proportions of ſulphur and tin are ſtill unknown, and could only be determined with accuracy by adding an exceſs of ſulphur to the pulverized ſulphuret made in the way above mentioned, and keeping the maſs juſt at fuſion in a cloſe retort as long as any ſulphur ſublimed from it.

This ſulphuret is a black brittle ſhining ſubſtance, of a flaky conſiſtence, and cloſely reſembling molybdena in appearance. When melted and cooled very ſlowly it aſſumes a lamellar texture, in the hollows of which are ſeen diſtinct needled and ſometimes cubic cryſtals.

This ſulphuret is not acted on by a ſolution of cauſtic potaſh.[u] When digeſted with nitric acid a large quantity of nitrous gas is given out, from which, and from the analogy with the other ſulphurets made by fuſion, we may conclude the metal to be in the reguline ſtate in this compound.

When a current of ſulphuretted hydrogen-gas is paſſed through any ſolution of ſuper-oxydated tin,[v] a yellow precipitate of *hydro-ſulphuretted ſuperoxyd* gradually collects, which takes place with more eaſe if a little alkali is previouſly added to the ſolution till the moment that a precipitate begins to appear. When the hydro-ſulphuret is *heated* with muriatic acid it again quits the oxyd of tin with effervefcence, and reſigns it to this acid. Hence it appears that the affinity of ſulphuretted hydrogen for this oxyd of tin is greater than that of muriatic acid in a low temperature, but leſs, when the heat is raiſed. When this yellow hydro-ſulphuret is dried it becomes vitreous in its fracture, it is eaſily ſoluble in potaſh, and precipitated thence by acids unaltered. When gradually heated *per ſe*, water, ſulphureous acid, and ſome ſulphur are given out, and the reſidue, if not overheated, is the golden ſulphuretted oxyd of tin, or *Aurum Muſivum*, which will be preſently deſcribed at large. The affinities that act in this proceſs are complicated. They are ſtated by Prouſt to be the following: the oxyd of tin gives out part of its oxygen, of which one portion unites to the hydrogen of the hydro-ſulphuret, and forms water, and the remainder carries off with it part of the ſulphur as ſulphureous acid; ſome exceſs of ſulphur beyond the requiſite proportions for the aurum muſivum is alſo volatized; whilſt the remainder of the ſulphur, and the tin, now in low oxydation, unite into the aurum muſivum which remains behind.

When ſulphuretted hydrogen gas is paſſed through a ſolution of ſub-oxydated tin, ſuch as the common muriat recently made, a dark coffee-coloured precipitate takes place, which is the *hydro-ſulphuretted ſub-oxyd*, and when waſhed with boiling water it dries of the ſame colour.

This hydro-ſulphuret is alſo decompoſed by muriatic acid with effervefcence in a boiling heat, but it gives no aurum muſivum when heated *per ſe*. When heated with a ſolution of cauſtic potaſh, both a ſolution and precipitation take place; the precipitate is the ſimple ſulphuret with the tin in the metallic ſtate; the ſolution on the other hand, is a hydro-ſulphuret of potaſh holding the metal in the higheſt ſtate of oxydation, ſince acids precipitate the hydro-ſulphuret yellow, like that firſt deſcribed. The potaſh therefore cauſes the condenſation of all the oxygen into a portion of the ſubſtance, together with all the hydrogen, at the expence of the other portion, which is then found deſtitute of both. This effect of potaſh, in concentrating all the oxygen into that portion which it diſſolves, is analogous to what occurs in other caſes, and depends on the much greater affinity of the ſuper-oxyd than of the ſub-oxyd for this alkali. A ſimilar action takes place when the ſub-oxyd of tin, ſulphur and ſolution of potaſh are heated together, and a hydro-ſulphuret of ſuper-oxydated tin is produced. In like manner if liquid muriated ſub-oxyd of tin is poured into liquid ſulphuret of potaſh, a yellow precipitate takes place, which is the ſuper-oxydated hydro-ſulphuret.

A beautiful golden-coloured ſpecies of ſulphuret of tin has long been known in the arts, under the name of *Aurum Muſivum*, or *Moſaicum*, *(Moſaic Gold)*. It is in the form of a ſcaly maſs, ſometimes cryſtallized in ſix-ſided plates, very ſoft and gloſſy to the touch, readily rubbed down between the fingers, and when the colour is brought out by a little friction, having a fine golden metallic luſtre. It is ſtill prepared in pretty large quantities by ſome artiſts, and is ſuppoſed to be uſed principally in artificial bronzing and other ornamental purpoſes. It was formerly employed in medicine. A great number of receipts have been given for preparing it, moſt of which ſucceed nearly equally well, provided the ſame attention to management of the heat, &c. be obſerved. It is alſo intereſting to experimental chemiſtry, and its properties have been examined by ſeveral excellent chemiſts, among whom may be enumerated Mr. Woulfe,[x] the Marquis de Bullion,[y] and M. Pelletier.[z]

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[s] Phil. Tranſ. vol. 61.

[t] Memoires, vol. 2.

[u] Prouſt Phyſ. tom 61.

[v] Ibid.

The old proceſs for aurum muſivum, and which is one of the beſt, is the following; as contained in the London Diſpenſatory.[a]

Take 12 oz. of tin, 7 oz. of flowers of ſulphur; ſal-ammoniac and quickſilver, of each 6 oz. melt the tin by itſelf, add to it the quickſilver, and when the amalgam is cold reduce it to powder, and mix it with the ſulphur and ſal-ammoniac, and ſublime the whole in a glaſs matraſs, ſtanding in a ſand-bath. Apply a gentle fire for ſome time, till the white fumes which ariſe copiouſly at firſt, begin to abate, then raiſe the fire till the ſand becomes red-hot, and keep it at this point, neither increaſing nor diminiſhing it, for a conſiderable time, according to the quantity of the materials, till you judge the operation to be compleated. The matraſs being broken when cold, the moſaic gold is found at the bottom, and above it a ſublimed ſubſtance, the compoſition of which will be preſently mentioned.

The moſaic gold therefore is not a *ſublimate*, but is a fixed ſubſtance, and it cannot be raiſed by heat unchanged. It weighs conſiderably more than the tin employed, but the actual product is extremely uncertain. A good deal of care is required in managing the fire, for if too ſlack none of the moſaic gold will be formed, and if urged beyond a moderate redneſs it is again decompoſed into a dark ſulphuret of tin, totally without luſtre. The proportions of the ingredients are variouſly given. Formerly equal parts of all the ſubſtances were employed, but they may be reduced to the proportions here given without diminiſhing the product.

As ſoon as the ingredients are mixed an odour of ſulphuretted hydrogen is given out, which increaſes rapidly as heat is applied; and if the proceſs be performed in a retort, with a receiver attached to it, a quantity of hydro-ſulphuret of ammonia or volatile liver of ſulphur, comes over, which condenſes in the extremity of the receiver, partly as a liquid and partly in beautiful cryſtalline needles. The ſublimate which is formed above the aurum muſivum, and which is much leſs volatile than the ammoniacal hydro-ſulphuret, is an extremely compound ſubſtance, (in the uſual way of preparing it) conſiſting chiefly of cinnabar, of muriated ammonia, and ſome muriat of tin, from which by a freſh ſublimation an additional quantity of the aurum muſivum may be obtained. This latter appears to be contained in the firſt ſublimate, and indeed may often be found interſperſed in it in ſhining hexagonal plates, but as aurum muſivum alone cannot be ſublimed, this portion is ſuppoſed to be formed by the muriat of tin and ſulphur combining in the act of volatilization.

The decompoſitions and changes that take place in the preparation of aurum muſivum with mercury, tin, muriat of ammonia, and ſulphur, are numerous and ſomewhat complicated. The principal ones appear to be the following: the mercury at firſt ſeems nearly paſſive in the operation, and ſerves merely to divide the tin, and render it eaſily reducible to powder, but when the heat is increaſed the mercury volatilizes and unites with the ſulphur into cinnabar. The tin is certainly firſt acted on by the ſal-ammoniac decompoſing the water which it contains, the oxygen of which it abſorbs, and the oxyd of tin thus produced is immediately diſſolved by the muriatic acid of the ſal-ammoniac forming a muriat of tin. This proceſs ſets at liberty two very volatile ſubſtances, viz. the hydrogen of the water decompoſed, and the ammonia of the ſalt, both of which, in volatilizing carry up a ſufficient quantity of the ſulphur preſent to conſtitute the hydro-ſulphuret of ammonia, which flies off in white fumes in the common way of proceeding, or, as already mentioned, may be collected in a receiver joined to the apparatus.

The ingredients in the matraſs are now changed, more or leſs compleatly, to muriat of tin, mercury, and ſulphur; and as the heat is increaſed all the mercury and part of the ſulphur ſublime, and unite into cinnabar; the muriat of tin is decompoſed by another part of the ſulphur, the muriatic acid is volatilized, taking with it a portion of the tin, and finally the remaining oxyd of tin and the reſt of the ſulphur, unite to form the aurum muſivum that remains at the bottom of the veſſel.

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[x] Phil. Tranſ. vol. 61.

[y] Journ. de Phyſ. tom. 20.

[z] Memoires de Pelletier.

[a] New Diſpenſatory for 1765.

It is to be obſerved that the ſole uſe of the mercury in this mixture is to enable the tin to be reduced to powder, ſo that the mixture may be ſimplified by omitting the mercury, provided the tin is reduced to powder, or otherwiſe divided. The ammonia of the ſal-ammoniac is alſo entirely ſuperfluous, and even the ſole uſe of the muriatic acid is to enable the tin to oxydate itſelf by the decompoſition of water, which it effects by the reſulting affinity of oxyd of tin for muriatic acid. So that in fact the only neceſſary ingredients for aurum muſivum appear to be oxyd of tin and ſulphur, the latter in conſiderably larger proportion than it exiſts in the black ſulphuret.

Theſe obſervations will be explained and illuſtrated by a ſhort abſtract of a variety of other proceſſes given by different chemiſts, by which aurum muſivum may be made.

The three following are given by Mr. Woulfe.

1. Take 10 oz. of black ſulphuret of tin, (formed by ſaturating melted tin with ſulphur) mix it with 4 oz. of ſulphur and 2 oz. of muriatic acid, calcine the mixture, and heat the reſidue in a matraſs in the uſual way. This gives a tolerably good aurum muſivum.

2. Take 4 oz. of tin, ſaturate it with ſulphur, powder it well, and mix it with 2 oz. of ſulphur and 1 oz. of cryſtallized muriat of tin. Calcine and heat as in the laſt proceſs. This gives 6½ oz. of a very fine aurum muſivum.

3. Mix 10 oz. of black ſulphuret of tin with 16 oz. of corroſive mercurial muriat, put it into a retort with a receiver adapted to it, and apply a heat for ſix hours, at firſt with a moderate fire, and for the laſt three hours the retort muſt be red-hot.

In this proceſs the mercurial muriat is decompoſed, a portion of the tin riſes highly oxydated, and united to the muriatic acid in the form of the ſmoking muriat; another portion remains behind, united with part of the ſulphur into very beautiful aurum muſivum, whilſt the oxyd of mercury unites with another part of the ſulphur into cinnabar.

The ſame experiment repeated by Pelletier, with equal parts of the two ingredients, gave the fuming muriat of tin, running mercury, and aurum muſivum.

Brugnatelli[b] gives the following receipt:

4. Precipitate a ſolution of nitrat of tin by liquid ſulphuret of potaſh; dry the precipitate, mix it with half its weight of ſulphur, and a quarter of ſal-ammoniac, and heat as uſual.

The following are ſome of the intereſting experiments of Pelletier on this ſubject.

5. A ſolution of 600 grs. of tin was made in muriatic acid; to this were added 600 grs. of ſulphur, and the whole was evaporated to dryneſs. It was then reduced to powder and heated in the uſual way, and gave a ſublimate of muriat of tin, mixed with a little ſulphur, and the reſidue at the bottom of the veſſel was very good aurum muſivum.

6. Equal parts of tin filings, ſulphur, and ſal-ammoniac, were duly heated: the volatile products were hydro-ſulphuret of ammonia, ſulphuretted hydrogen gas, ſulphur, and ſome ſal-ammoniac, and very fine aurum muſivum remained.

7. Equal parts of black ſulphuret of tin and muriat of ammonia were mixed and heated. The reſidue was a black, irideſcent, friable, puffy maſs, very different from the ſimple ſulphuret, and appeared to be oxyd of tin, not ſaturated with ſulphur; and in this latter circumſtance therefore differing from aurum muſivum. This was confirmed by the following.

8. Equal parts of the black ſulphuret of tin, of ſal-ammoniac, and of ſulphur, were heated as above, and a good quantity of fine aurum muſivum was obtained. As there was more ſulphur than neceſſary, ſome ſulphuret of ammonia was ſublimed.

9. Equal parts of cinnabar and black ſulphuret of tin heated together, gave running mercury and aurum muſivum. Cinnabar conſiſts of ſulphur and oxyd of mercury, ſo that the ſulphuret of tin in this experiment deprived the cinnabar both of its oxygen and its ſulphur.

10. Equal parts of tin putty *(ſub-oxyd of tin)* and ſulphur gave, after much of the exceſs of ſulphur had ſublimed off, a black brittle maſs, viſibly penetrated with ſulphur, but no aurum muſivum.

11. Some tin putty was calcined with nitre, and thus converted into a white oxyd. Of this, 600 grs. were heated with 400 of ſulphur, and the products were, ſulphur and ſulphureous gas, and aurum muſivum.

12. The oxyd of tin, precipitated from the muriat by ſoda, and mixed with ſulphur, gave the ſame products as the laſt.

13. The oxyd of tin by nitric acid, mixed

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[b] An. Chim. tom 29.

with two-thirds of its weight of ſulphur, gave the ſame products as the laſt.

In examining theſe experiments it appears that aurum muſivum may be made ſimply by heating ſulphur and oxyd of tin, but the three laſt experiments ſhew that it is neceſſary for the tin to be in a ſtate of high oxygenation.

Nevertheleſs, as in theſe ſimple proceſſes ſome of the ſulphur is converted into ſulphureous acid, for the oxygen of which no other ſource but the oxyd of tin appears, it may be doubted whether the tin remains in the higheſt ſtate of oxygenation in the aurum muſivum, though there can be no doubt that it is oxydated to a certain degree.

We may therefore conſider this ſubſtance as a ſulphuretted oxyd of tin, in which the oxyd is ſaturated with as much ſulphur as it can retain at a low red heat.

Aurum muſivum may be made as well, and much more economically, in a crucible as in glaſs veſſels. To make 10 or 12lb. of it requires about eight hours; but for an ounce or two in ſmall experiments about an hour will ſuffice.

Aurum muſivum, when well prepared, is without taſte, and entirely inſoluble in water. The acids have no effect on it. When muriatic acid is boiled with it, ſome ſulphuretted hydrogen is generally given out and a little tin diſſolved, but this is owing to the admixture of a portion of ſulphuret of tin, for if the reſidue is waſhed, no ſubſequent treatment with this acid produces any effect. It is in this reſiſtance to the action of muriatic acid, that aurum muſivum is particularly diſtinguiſhed from the ſimple ſulphuret and the more and leſs oxydated hydro-ſulphurets of tin.

When aurum muſivum is digeſted with a ſolution of potaſh and heated, it quietly diſſolves and forms a green liquid, from which acids ſeparate a yellow powder, which is the ſuperoxydated hydro-ſulphuret, and not regenerated aurum muſivum.

If moſaic gold is heated ſtrongly in a cloſe veſſel, (that is, to as full a red heat as a glaſs retort will bear) it is entirely altered in its nature, a large quantity of ſulphureous acid gas is given out, ſome ſulphur ſublimes, and the reſidue, which is nearly five-ſixths of the whole, is a black brilliant metallic-looking maſs, which appears to be chiefly ſulphuret of tin. A ſtrong heat therefore cauſes the union of part, it not all, of the oxygen of the aurum muſivum, with that portion of the ſulphur which flies off as ſulphurous acid.

Phoſphorus unites with tin with great eaſe, either directly by projecting phoſphorus on melted tin, or by heating vitreous phoſphoric acid or phoſphat of ammonia with tin, with or without the addition of charcoal.[c] In the former method a white regulus is obtained, cryſtallized externally, weighing from 12 to 15 per cent. more than the tin. When this phoſphuret is diſtilled with corroſive mercurial muriat, the products are ſmoking muriat of tin, running mercury, and phoſphuretted hydrogen gas, and in the retort there remains a tumid maſs, compoſed of phoſphorus and oxyd of tin. When equal parts of vitreous phoſphoric acid and tin filings are heated together, after the mixture has been a little time in fuſion, flaſhes of inflamed phoſphorus break up from the ſurface, and if it is immediately afterwards removed, two diſtinct ſubſtances are found in the crucible, the loweſt of which is phoſphuret of tin, which is ſoft enough to be cut by the knife; when hammered it extends, but ſplits into laminæ; has a ſilvery luſtre in the recently divided ſurface, and burns before the blowpipe with a phoſphoric flame, and a globule of pure tin is left, covered by a tranſparent glaſs. Above the phoſphuret of tin is a black glaſs, conſiſting of oxyd of tin and phoſphoric acid. In this proceſs both the tin and the phoſphoric acid are divided into two portions, part of the tin is converted into oxyd of tin by deoxygenating a part of the phoſphoric acid, and fuſes with the remainder of the acid into a black glaſs: whilſt the reſt of the tin unites with the deoxygenated phoſphoric acid (that is to ſay, the phoſphorus) into the metallic phoſphuret. This decompoſition takes place at a very moderate heat, ſcarcely more than what is required for the fuſion of tin.

Tin unites with moſt of the metals, and ſome of theſe alloys are much uſed in the arts. Of theſe the moſt important are: the alloy of tin and copper, with other additions, which forms bronze, bell-metal, ſpeculum-metal, &c. and which has been deſcribed under the article Copper *(Alloys of)*: the alloy of tin and lead in equal parts, which forms the common plumber's ſolder: the alloy of tin, lead, and biſmuth, which forms the very fuſible compounds deſcribed under Bismuth: the amalgam of tin and mercury uſed in ſilvering mirrors, the proceſs of which is mentioned under the article Glass, and the alloy commonly called Pewter.

Pewter was formerly more extenſively uſed than, perhaps, any other metallic alloy, being the common material for plates, diſhes, and other domeſtic utenſils, but its uſe is now almoſt univerſally ſuperſeded by pottery, which is lighter, more eaſily kept clean, and cheaper, though leſs durable. The name of pewter has been given to any malleable white alloy into which tin largely enters, and its compotion is ſo various that hardly any two manufacturers employ preciſely the ſame ingredients and in the ſame proportion. The fineſt kind of pewter contains no lead whatever, but conſiſts of tin with a ſmall alloy of antimony, and ſometimes a little copper. Wallerius gives the proportions of 12 parts of tin, 1 of antimony, and about $\frac{1}{48}$ of copper.[c] A very fine metal is made of 100 parts of tin, 8 of antimony, 1 of biſmuth, and 4 of copper. The uſe of theſe additions to the tin is to harden it, and preſerve its whiteneſs, and this fine kind of pewter takes a very high poliſh, has a beautiful ſilvery luſtre, and is not readily tarniſhed. Tin, with a little zinc or braſs, makes a very fine hard alloy. In all theſe ſuperior kinds of pewter, the tin forms by far the greater part of the mixture.

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[c] Pelletier.

It is to be obſerved that the antimony is ſo intimately united to the tin, that it is not volatilized when ſtrongly heated, or only in a very ſmall degree, and it is not eaſily diſſolved by any weak acid, ſo that there is no danger of producing the common effects of this metal in employing this kind of pewter. There is a natural limit to the uſe both of all the brittle metals, and of copper in alloying tin, which is the brittleneſs which they impart to the alloy when they exceed certain proportions. But it is not ſo with lead, which may be mixed with tin in any proportion, and the alloy will remain perfectly malleable; and this, with or without other ſmaller additions, forms the ordinary pewter, ſuch as is uſed for meaſures for liquor, and many ſmaller purpoſes, and in other countries of Europe, for many other domeſtic uſes. As lead is by much the cheapeſt of the two metals, it is the intereſt of the manufacturer to employ it in as large a proportion as poſſible, but as much danger to health may be apprehended from this noxious metal, this ſubject was examined particularly by a commiſſion from the French government of ſome very able chemiſts. Theſe gentlemen found, that when wine or vinegar is allowed to ſtand in veſſels compoſed of an alloy of lead and tin in different proportions, the tin is firſt diſſolved, that the lead is not ſenſibly oxydated by theſe liquors, except at the line of contact of the air and the liquor, and that no ſenſible quantity of lead is diſſolved even by vinegar after ſtanding for ſome days in veſſels that contained no more than about 18 per cent. of lead. Therefore as no noxious effect is produced by the very minute quantity of tin which is diſſolved, a pewter may be conſidered as perfectly ſafe which contains about 80 or 82 per cent. of tin; and where the veſſels are employed merely for meaſures, a much leſs proportion of tin may be allowed. But the common pewter of Paris was found to contain no more than about 25 or 30 per cent. of tin, and the remainder was lead. The ſpecific gravity of a mixture of tin and lead is *leſs* than the mean ſpecific gravity of the ſame proportion of the two metals ſeparately, conſequently the bulk of the alloy is greater than the bulks of the metals before union, which is the contrary to what happens in moſt other alloys. This alloy when in equal parts forms alſo the common plumbers' ſolder. When melted it oxydates at its ſurface with great rapidity, much more than even either of the metals ſeparately, and this oxyd is the baſis of the fineſt *Enamel White*.

The uſes of tin are conſiderable. It is employed for many purpoſes in fine leaf about the thickneſs of writing paper, when it is called *Tin-foil*. This is made from the very fineſt tin which is firſt caſt into an ingot, then laminated to a moderate extent, and afterwards beat out with a hammer, with very great manual labour and ſkill till it is brought to the requiſite thickneſs, and extended perfectly uniformly without any flaw or break. The other uſes of tin are, very largely, for tinning iron and copper, in pewter, ſolder, and other alloys; and the ſalts of this metal are employed in dyeing.

TINNING *of Iron and Copper*. See Iron and Tin.

TINCAL. See Borax.

TINGLASS. See Bismuth.

TINCTURE. A tincture is commonly underſtood to be a coloured infuſion of any ſubſtance in alcohol. It is a preparation much employed in pharmacy with many of the articles of the materia medica, particularly vegetable barks, aromatics of all kind, and many of the reſins and gum-reſins, which yield to alcohol by infuſion that part of their ſubſtance in which moſt of the medicinal virtue reſides.

TITANIUM.

This is a metal of a copper red colour, very difficult of fuſion, ſoluble in muriatic acid, and precipitable from this menſtruum of a blood red colour by tincture of galls.

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[c] Leonhardi Worterbuch.

§. 1. *Ores.*

Sp. 1. Titanite. *Ruthil,* Wern. *Ruthile,* Broch. *Titane oxydé,* Hauy. *Red Schorl,* of the older mineralogiſts.

Its colour is dark blood red, paſſing into reddiſh brown and copper red. It occurs only cryſtallized. Its primitive form is a ſtrait priſm with a ſquare baſe. The other forms that it preſents are moſt commonly geniculated, that is, united by one of its extremities with a ſimilar cryſtal, ſo that the two together form a very obtuſe angle. Sometimes it happens that a cryſtal is terminated only by a ſmall fragment of another, giving to it the appearance of an imperfect pyramidal termination. Beſides the above aſcertainable forms, capillary cryſtals are not unfrequently met with; they are either ſingle, or bundled or grouped together like net work, the interſtices being in the form of equilateral triangles. The larger cryſtals are longitudinally ſtriated. The principal fracture of this mineral is foliated in two directions, with a luſtre brightly ſhining, between ſemi-metallic and adamantine; its croſs fracture is imperfectly conchoidal, paſſing into uneven, with a gliſtering luſtre. The thin cryſtals are ſlightly tranſlucent, the others are moſtly opake. Its hardneſs is nearly equal to that of quartz, but it is brittle and eaſily frangible. Sp. gr. 4.1—4.24.

It is infuſible without addition before the blowpipe, but with borax it forms a glaſs of a hyacinthine red colour, which by expoſure to the external blue flame, becomes ſucceſſively blue, green, and white. When expoſed to a high heat in a charcoal crucible it breaks to pieces, and becomes of a pale brown colour.

The titanite of Hungary has been analyſed by Klaproth, and appears to be pure oxyd of titanium mixed with a little ſilex; that from Spain appears from the ſame authority to be at leaſt equally pure. The titanite of Aſchaffenburg according to Klaproth, and that of Friuli according to Vauquelin, contain a minute portion of manganeſe and iron.

It occurs near Roſenau in Hungary, and at Cajuelo near Buitrago in New Caſtille in Spain, implanted in rock cryſtal, in a mountain of gneiſs; at St. Gothard, in the cavities of granite mixed with rock-cryſtal, adularia, and chlorite: in the Saltzburg mountains imbedded in tremolite; near St. Yrieix in la Haute Vienne in France, in rounded cryſtals diſperſed in an alluvial bed. It has alſo been found at Sarapulka in Siberia, and in New Granada in S. America.

Sp. 2. Octohedrite. *Anataſe,* Hauy.

This mineral has already been deſcribed under the name ANATASE, which ſee.

Sp. 3. Calcareo-ſiliceous titanite. *Titanit,* Klapr. *Nigrine,* Broch. *Titane ſiliceo-calcaire,* Hauy.

Its colour is browniſh-red, blackiſh-brown, yellowiſh-brown, and yellowiſh-white. It occurs maſſive, diſſeminated, and cryſtallized.

Its primitive form is a ſtrait rhomboidal priſm, the alternate angles of which meaſure 137° and 43°.

The other forms that it preſents are,

1. A rhomboidal priſm with dihedral ſummits, in which the lateral faces are trapeziums, and the terminal ones triangles.

2. The ſame with each of the terminal ſolid angles replaced by two triangular facets, thus making the planes of the priſm lengthened hexagons, while thoſe of the ſummit conſiſt of four triangular and two pentagonal facets.

The cryſtals are ſmall and commonly imbedded ſingly. Its longitudinal fracture is foliated, paſſing into radiated with a gliſtening luſtre; the croſs fracture is flat-conchoidal paſſing into even, and has little or no luſtre. It is opake, but ſometimes tranſlucent on the edges. It is conſiderably hard, but brittle and eaſily frangible. Sp. gr. 3.48—3.51.

When expoſed without addition to the blowpipe it only ſhews a commencement of fuſion; in a clay crucible it undergoes no change at an intenſe heat; but in a charcoal crucible it melts at a high temperature into a black opake ſcoria.

Specimens of this mineral from Paſſaw have been analyſed by Klaproth, others from Arendahl by Abildgaard, and others from St. Gothard by Cordier, with the following reſults,

Klapr.	Abild.	Cord.	
33	58.74	33.31	Oxyd of Titanium
35	22.08	28.	Silex
33	20.18	32.	Lime
101	101.00	93.3	

The dark coloured cryſtals alſo contain oxyd of iron, according to Vauquelin.

It occurs in the neighbourhood of Paſſaw in Bavaria, at Buoen in Norway, and at St. Gothard in Switzerland.

Sp. 4. Menachanite. *Menachan & Nigrin,* Wern. *Titane oxydé ferrifére.* Hauy.

Its colour is iron-black paſſing to greyiſh and browniſh-black. It occurs in flattiſh angular grains and ſmall lumps. Its internal luſtre is moderately gliſtening, between ſemi-metallic and adamantine. Its fracture is imperfectly foliated, paſſing into fine-grained uneven. It is opake; is brittle but hard, ſo as not to be eaſily pulverizable. Its ſp. gr. when in ſmall grains is not readily determined, when in larger pieces it amounts according to Klaproth as high as 4.74.

Some varieties are nearly as magnetic as iron ſand; others though not attractible by the magnet are yet capable of affecting the polarity of a ſuſpended magnetic needle; while other varieties have no action whatever on the magnet.

This mineral conſiſts of oxyd of titanium combined with oxyd of iron and a little manganeſe, but the proportions are liable to much variation. The following are the reſults of ſome of the principal analyſes.

From	Cornwall	Aschaffenburg	Ohlâpiân	Bavaria	Botany Bay	Uralian Mountains	
By	Klapr.	Klapr.	Klapr.	Vauq.	Chenevix	Lowitz	
	45.25	22.	84.	49.	40.	53.	Oxyd of Titanium
	51.	78.	14.	49.	49.	47.	Oxyd of Iron
	0.25	0.	2.	2.	0.	0.	Oxyd of Manganeſe
	3.5	0.	0.	0.	11.	0.	Silex
	100.	100	100	100	100	100	

It was firſt diſcovered by Mr. Gregor mixed with quartz ſand, in the bed of a rivulet in the valley of Menachan in Cornwall. It has ſince been found imbedded in quartz near Aſchaffenberg in the Speſſart foreſt; alſo at Bodenmais in Bavaria, at Ohlâpiân in Hungary in auriferous ſand; in the Uralian mountains in Siberia, and at Botany Bay in New Holland, &c.

Sp. 5. Iſerin.

Its colour is iron-black inclining to browniſh. It occurs in ſmall angular grains and in rolled pieces, with a rough ſtrongly glimmering ſurface. Internally it is gliſtening with a ſemi-metallic luſtre. Its fracture is more or leſs perfectly conchoidal. It is opake, hard, and brittle. Sp. gr. 4.5.

Before the blowpipe it melts into a blackiſh brown glaſs, which is ſlightly attracted by the magnet. It is ſaid to be compoſed of,

59.1	Oxyd of Titanium
30.1	Oxyd of Iron
10.2	Oxyd of Uranium
99.4	

It has hitherto been found only in the Rieſengebirge, near the ſource of the river Iſer, in granite ſand.

§. 2. *Analyſis of Ores.*

The analyſis of the ores of titanium, though very ſimple, is however very imperfect, as we are hitherto almoſt entirely unacquainted with the compoſition either of the ſalts or oxyds of this metal.

The only menſtruum of ſufficient activity to be employed in the analyſis of theſe ores is fixed alkali, and this is more efficacious when carbonated than when cauſtic. The method followed both by Klaproth and Vauquelin, in the analyſis of titanite, is the following.

a. Having ground the ore to a very minute powder, let it be mixed with five or ſix times its weight of carbonated potaſh, and brought to a ſtate of fuſion in a crucible. The melted maſs when poured out will be of a green colour if any iron and manganeſe are preſent, but otherwiſe of a pearl-grey colour. The fuſed maſs after being pulverized, is to be digeſted in repeated portions of hot water, till every thing ſoluble is extracted, after which there will remain a reddiſh white powder, which is nearly pure carbonat of titanium.

b. The alkaline ſolution contains only a little ſilex and alumine, with the oxyds of manganeſe and iron, which are to be ſeparated in the uſual way.

The calcareo-ſiliceous titanite was thus analyſed by Klaproth.[b]

a. 100 grs. finely pulverized were ignited for an hour with four times their weight of cauſtic potaſh, the reſulting maſs was ſoftened with water, and digeſted with an exceſs of muriatic acid; the whole was thus diſſolved except 12 grs. of ſilex.

b. The muriatic ſolution was decompoſed by

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[a] Klapr. Analyt. Eſſ. Vol. I. p. 496. Journ. des Mines, No. 15, p. 12.

[b] Analyt. Eſſ. Vol. I. p. 214.

carbonated potaſh, and the precipitate thus obtained, after being waſhed and dried, was again digeſted with muriatic acid, which left behind 23 grs. of ſilex.

c. The preceding ſolution was now combined with cauſtic ammonia, which threw down 62 grs. of a yellowiſh white precipitate, that was ſubſequently reduced by ignition to 33 grs. and was pure oxyd of titanium.

d. The reſidual fluid when ſaturated at a boiling heat by mild potaſh, afforded 33 grs. of carbonated lime.

The menachanite of Bavaria was thus analyſed by Vauquelin.[c]

a. 100 grs. finely pulverized were melted in a ſilver crucible with 400 grs. of cauſtic potaſh, during an hour and a half. The fuſed maſs was of a green colour, and afforded with water a green ſolution, a brick red powder weighing 124 grs. remaining behind.

b. The above 124 grs. were boiled for an hour with cauſtic potaſh, and the ſolution after ſaturation with muriatic acid was treated with carbonat of potaſh, which threw down 3 grs. of oxyd of titanium.

c. The reſidue of the 124 grs. was digeſted with dilute muriatic acid, which ſoon acquired a yellow colour, and left behind 46 grs. of a reddiſh white powder, which was oxyd of titanium.

d. The yellow muriatic liquor was ſaturated by ammonia, and afforded 50 grs. of brown oxyd of iron.

e. The green alkaline ſolution *(a)* was ſuperſaturated with muriatic acid, and acquired a bright red colour, which during evaporation entirely diſappeared. The ſaline reſidue was again perfectly ſoluble in water, thus ſhewing the total abſence of ſilex; on the addition of carbonated potaſh, it yielded a precipitate weighing 2 grs. which was carbonated manganeſe.

§. 3. *Chemical Properties.*

Several attempts, though with but imperfect ſucceſs, have been made to reduce titanium to the metallic ſtate. The ſalt ſelected for theſe experiments by Vauquelin,[d] was the carbonat, which after being formed into a paſte with fiſh oil, was placed in a crucible lined with a mixture of clay and charcoal, and expoſed for three quarters of an hour to an intenſe heat. A blackiſh ſpungy maſs was thus obtained, which in ſome parts preſented a reddiſh metallic appearance.

In another experiment 100 parts of native titanite were mixed with 50 parts of calcined borax, and an equal quantity of charcoal; the maſs thus produced was placed in a lined crucible, and heated for an hour and a half in a forge furnace. An agglutinated brittle maſs was thus obtained, the external colour and luſtre of which greatly reſembled that of copper. Being broken and expoſed to the air while it was yet hot, its red colour paſſed in ſome places to purple and then to blue. Lampadius[e] is ſaid to have ſucceeded ſtill more compleatly, by decompoſing the gallat of titanium by means of fixed alkali, and ſtrongly heating the oxyd thus obtained in a charcoal crucible. The reſult of this proceſs is a metallic maſs of a dark copper colour with conſiderable brilliancy; it is very infuſible, is compoſed of ſlightly cohering ſcales which individually are moderately elaſtic. It tarniſhes by expoſure to the air, is converted by heat to a blue oxyd, detonates with nitre, and is readily acted on by all the ſtrong acids. The metallic maſs obtained by Vauquelin, exhibited the following properties with acids. The nitro-muriatic acid converted it ſuperficially into a white pulverulent oxyd. The muriatic acid diſengaged a large quantity of hydrogen gas, and a conſiderable quantity of white flocculent oxyd was obſerved floating in the liquor. Concentrated ſulphuric acid at a boiling temperature, diſſolved a portion and converted the remainder to a white oxyd, ſulphureous acid gas being diſengaged; and the ſulphat of titanium thus produced exactly reſembled that obtained by the oxyd of this metal.

Titanium appears capable of three ſtates of oxydation, diſtinguiſhed by the colours blue, red, and yellowiſh white, the latter being the ſaturated or per-oxyd. With regard to the proportion of theſe two ingredients in the different oxyds, ſcarcely any thing certain is known, only it may be concluded with ſome probability from the reſult of an analyſis by Vauquelin, that the red oxyd in paſſing to the ſtate of white oxyd acquires about 18 per cent. From the ſame experiment by Klaproth indeed, it would be concluded that the augmentation was about 24 per cent.; the difference is not very great, and the truth may perhaps lie between.

The white oxyd when heated acquires a lemon yellow colour, which however diſappears again in proportion as it cools. In this ſtate it yields a little to concentrated ſulphuric acid, but is not diſſolved by any other liquid menſtruum either acid or alkaline. By fuſion with a carbonated alkali it is converted to a carbonat inſoluble in water, and therefore capable of being readily ſeparated by this fluid from the mixed alkali.

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[c] Journ. des Mines, No. 19. p. 58.

[d] Ditto, No. 15. p. 21.

[e] Phil. Mag. Vol. xvii. p. 95.

Carbonat of titanium is ſoluble in the cold, by either of the three mineral acids moderately diluted, the carbonic acid eſcaping at the ſame time by effervеſcence, but on heating theſe ſolutions they are all decompoſed, a white oxyd being precipitated, or rather half ſeparating from the liquid ſo as to make it white like milk. When the nitrat of titanium is thus heated, there is a conſiderable diſengagement of nitrous gas previous to its decompoſition, which ſhows that in this caſe the oxyd becomes inſoluble by abſorbing an additional portion of oxygen. When the muriat of titanium on the other hand is decompoſed by heat, there is a very ſenſible diſengagement of oxymuriatic acid, thus ſhewing that the inſolubility of the oxyd in this caſe is owing to its being deprived of a portion of oxygen. This ſingular circumſtance is further demonſtrated by the ready ſolubility in muriatic acid of the oxyd that has been depoſited from the nitrat.

The alkalies both cauſtic and carbonated decompoſe the ſalts of titanium, throwing down a white oxyd in the one caſe, and a carbonated oxyd in the other. The arſenic and phoſphoric acids alſo throw down a white precipitate. The tartareous and oxalic acids afford a white precipitate, reſoluble in an additional portion of acid. Hydroſulphuretted water occaſions no turbidneſs, but an alkaline hydroſulphuret affords a dirty browniſh green precipitate; the green colour however is probably owing to a ſlight contamination of iron. Pruſſiat of potaſh affords a copious precipitate of a green colour, which does not become blue by expoſure to the air according to Vauquelin, of a graſs-green colour mixed with brown according to Klaproth, but of a dirty yellowiſh brown according to Lowitz; a muriatic ſolution of the titanium in anataſe was obſerved by Vauquelin to give with pruſſiat of potaſh a cheſnut brown precipitate. Tincture of galls, or gallic acid, throws down a bulky browniſh red precipitate, which, except the ſolution is much diluted, in a ſhort time becomes clotted like blood: this precipitate when waſhed and dried greatly reſembles kermes mineral.

If into a vial filled with muriat of titanium there be put a ſtick of tin, and the vial be cloſed by a ſtopper, a faint roſe colour will ſoon be viſible in that part of the ſolution adjacent to the tin, which by degrees will deepen to an amethyſtine red, and extend through the whole liquor. If a ſtick of zinc be ſubſtituted to the tin, the colour of the ſolution will be firſt violet and at length indigo-blue: this coloured liquor when gently warmed in a ſhallow veſſel in contact with the air, will loſe its colour, and depoſit a bulky white precipitate, again ſoluble in muriatic acid, and apparently differing in nothing from the original muriatic ſolution.

It is not known whether titanium combines with ſulphur, it may be made however to unite with phoſphorus in the following way. Mix the phoſphat of titanium with charcoal and borax, and heat the maſs ſtrongly in a blaſt furnace, the reſult will be a button of titanium of a pale white colour, and metallic luſtre.

Various attempts have been made by Vauquelin to alloy titanium with the other metals, but wholly without ſucceſs, where lead, arſenic, copper and ſilver, were employed, and with only very dubious ſucceſs, when iron was made uſe of.

Both the white oxyd and titanite in ſubſtance, according to Klaproth, afford when mixed with enamel flux, a ſtraw-yellow colour, and it appears from Le Lievre, that it was uſed in the porcelain manufactory at Sévres as an ingredient in the rich browns, but the difficulty of obtaining from it an uniform tint, has at length occaſioned it to be abandoned.

TOADSTONE. See Trap.

TOEPFERTHON. See Clay potters'.

TOPAZ. Topas, *Wern.* Topaze, *Hauy* and *Broch.* Topaz of Brazil, of Saxony, and of Siberia. Occidental Topaz.

Its moſt uſual colour is wine yellow of different degrees of intenſity; it alſo occurs nearly colourleſs, yellowiſh and bluiſh white, and pale ſky-blue, alſo greeniſh-grey, roſe-red, and peach-flower red.

It is found in maſs, diſſeminated, in rolled fragments, and cryſtallized. Its primitive form is a ſtrait priſm, with rhomboidal baſes, the alternate angles of which meaſure 124° and 56°.

The other varieties of cryſtallization that it preſents are the following.

1. An eight-ſided priſm, the planes of which join one another, forming two oppoſite angles of 124°, two others of 93°, and four others of 161°. The priſm is terminated by tetrahedral pyramids.

2. The preceding, with the edges of the terminal pyramid that adjoin the two ſmalleſt angles of the priſm very deeply truncated, ſo as to form ſometimes a hexahedral, and ſometimes

even a cuneiform ſummit; the former termination is obſervable in the Braſilian, and the latter in the Siberian topazes.

3. The preceding, with a hexahedral ſummit deeply truncated, ſo as to form a regular hexagonal plane.

4. The preceding, with the edges of the priſm that are adjacent to the two ſmalleſt angles replaced each by two ſecondary planes, thus forming a dodecahedral priſm.

5. The preceding, with the lateral, and ſometimes the vertical edges of the ſummit bevilled.

The cryſtals are generally ſmall and middle ſized; their lateral faces are generally longitudinally ſtreaked, and ſometimes convex. The luſtre both externally and internally, is uſually brightly ſhining, vitreous. The croſs fracture is ſtrait lamellar, the longitudinal is ſmall and imperfectly conchoidal. It varies from tranſparent to tranſlucent, and poſſeſſes a double refraction. When in maſs it occurs in coarſe and fine granular diſtinct concretions. It ſcratches quartz but is inferior in hardneſs to the ruby. It is eaſily frangible. Sp. gr. 3.46—3.56.

It is infuſible *per ſe* before the blowpipe, but melts without intumeſcence by the aſſiſtance of borax. The Saxon topaz by a gentle heat becomes colourleſs without undergoing any other change, and in this ſtate is ſometimes ſold for diamond; at a higher heat however it becomes opake. The Brazilian topaz, when ignited in a crucible, becomes of a roſe-red colour, and is then often called by the jewellers Brazilian ruby.

The Brazilian and Siberian topazes are rendered electric by heat.

According to the firſt analyſis of this mineral by Vauquelin, its component parts appeared to be,

31	Silex
68	Alumine
99	

Klaproth however afterwards detected the preſence of fluoric acid in conſiderable abundance, which induced a ſecond analyſis of it by Vauquelin,[a] according to which it conſiſts of,

29	Silex
50	Alumine
21	(or thereabouts) Fluoric acid
100	

Topaz occurs at Schneckenſtein in Saxony mixed with quartz, black ſchorl, mica and lithomarga, forming an aggregate which has obtained the name of topaz rock. It is found in Bohemia at Schlackenwald in veins mixed with tinſtone, fluor ſpar and miſpickel. The Siberian topazes are found in the Uralian mountains, near Ekaterinenburg, and in Daouria in the mountain Odontchelon, imbedded in graphic granite, and accompanied by blackiſh quartz and aquamarine. Topaz alſo occurs in Brazil, and at Muckla in Natolia, alſo in Pegu and Ceylon.

It ranks as one of the gems, but is not very highly valued.

TOPAZ Oriental. See CORUNDUM.

TOPAZ falſe. See FLUOR SPAR and QUARTZ.

TOPFSTEIN. See POTSTONE.

TOUCHSTONE. See KIESELSCHIEFER.

TOURMALINE. See SCHORL in the Addenda at the end of the volume.

TRAGACANTH GUM. See MUCILAGE.

TRANSFER. An article of apparatus, for a deſcription of which ſee the Appendix.

TRAP.

The term Trap is Swediſh, and ſignifies a ſtair. It was firſt applied about ſixty years ago, by ſome Swediſh mineralogiſts to deſignate a certain claſs of mountains, compoſed of nearly horizontal ſtrata with perpendicular breaks, which thus preſented a rude reſemblance to a flight of ſtairs. In conſequence of the vagueneſs of this eſſential character, many ſpecies of rock differing very much from each other were called by the ſame name, and inextricable confuſion would ſoon have enſued, if Werner had not by adopting and reſtricting the term, beſtowed on it a definite meaning.

According to Werner there are three diſtinct claſſes or formations of rocks to which the term trap may be applied. Of theſe, the firſt claſs belongs to the primitive mountains, the ſecond to the tranſition mountains, and the third to the ſecondary mountains.

§ 1. *Primitive Traps.*

The primitive traps are compoſed eſſentially of hornblende, not unfrequently mingled with felſpar, and more rarely with pyrites and mica. There are four diſtinct ſpecies of rocks belonging to this formation, namely common hornblende, ſchiſtoſe hornblende, primitive grünſtein and ſchiſtoſe grünſtein.

The *common hornblende* rock is no other than the ſubſtance already deſcribed in the article

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[a] Journ. des Mines, No. 96, p. 469.

Hornblende. It is ſometimes a congeries of large imperfect cryſtals, but more generally of grains, which laſt are often ſo minute as to give the whole rock a compact appearance.

Schiſtoſe Hornblende rock is for the moſt part compoſed of the ſubſtance from which its name is derived; it is however occaſionally mixed with quartz, actynolite and pyrites. This rock does not excluſively belong to the trap formation as it forms ſubordinate beds in gneiſs, micaceous ſchiſtus, and argillite. It paſſes ſometimes into grünſtein.

Primitive grünſtein, or green ſtone, ſo called from its colour, is an aggregate of hornblende and felſpar. It differs in little or nothing except its ſituation from ſienite. There are three varieties of this rock; in one the hornblende and felſpar are intimately and immediately aggregated and its texture is ſimply granular; in the ſecond variety, the grains of which it is compoſed are ſmaller than in the preceding, and in this aggregate, as in a paſte, are imbedded cryſtals of felſpar; hence its texture is at the ſame time finely granular and porphyritic; in the third variety the particles of felſpar and hornblende compoſing the paſte, are ſo minute as to be indiſtinguiſhable, hence its fracture is compact and even ſplintery; in this are imbedded cryſtals of felſpar. The green antique porphyry belongs to this variety.

Schiſtoſe grünſtein is compoſed of compact felſpar and hornblende in nearly equal proportions, mixed with a little mica, and more rarely, with quartz: it has a ſchiſtoſe texture.

This rock is not peculiar to the primitive trap formation, being found ſometimes to alternate with argillite.

Grünſtein is not unfrequently traverſed by metalliferous veins.

§ 2. *Traps of Tranſition.*

The principal material of the rocks that belong to this formation is granular grünſtein; but in the tranſition traps the mixture of the ingredients is more intimate, the grain is finer, and the maſs appears more homogeneous. The two following are its principal varieties.

Amygdaloid.—Toadſtone, Mandelſtein.

The maſs of this rock is ſchiſtoſe hornblende or ſchiſtoſe grünſtein in a ſtate of ſemi decompoſition reſembling Wakke or fine ferruginous clay. It contains a number of globular cavities from the ſize of a pea to that of a ſmall apple; of theſe cavities ſome contain nothing but air, and are coated on the inſide with a kind of varniſh; others contain balls of calcareous ſpar, quartz, and chalcedony, the latter compoſed of concentric layers round a hollow nucleus lined with cryſtals of quartz. The toadſtone of Derbyſhire is conſidered by Werner to belong to this variety.

Globular Trap. Kugeltrap.

This is compoſed of ſchiſtoſe grünſtein in a ſtate of ſemi-decompoſition, arranged in ſpheroids of various magnitudes, and compoſed of thick concentric lamellar diſtinct concretions.

The traps of tranſition appear not to be ſtratified; they form ſolitary conical mountains in the vicinity of tranſition limeſtone, and contain very few metallic veins.

§ 3. *Secondary, or Floetz Traps.*

The rocks or ſtrata belonging to the ſecondary trap formation may be divided into thoſe which are peculiar and characteriſtic of it, and thoſe which are accidental. The former are baſalt, wakke, baſaltic trap, ſecondary amygdaloid, klingſtein porphyry, grauſtein, and ſecondary grünſtein. Among the latter may be claſſed, rubble and ſandſtone, clay, coal, and bituminous wood.

Baſaltic rock, is compoſed for the moſt part of the mineral already deſcribed in the article baſalt. It is uſually porphyritic, and then contains cryſtals or grains of felſpar, olivine, augite, baſaltic hornblende, magnetical iron, leucite, quartz, and, rarely, mica, actynolite, and chalcedony. Sometimes it aſſumes the amygdaloidal ſtructure, and its cavities are then either empty or filled with zeolite, ſteatite, calcareous ſpar, and even ſometimes with water. Of all the rocks belonging to the ſecondary trap formation, baſalt is of the moſt frequent occurrence; it forms by itſelf whole mountains, and the entire ſeries of rocks with which it is aſſociated, may be with much propriety, and is actually by ſome mineralogiſts, denominated the baſaltic formation.

Wakke rock is compoſed of the mineral bearing this name, mixed with cryſtals of baſaltic hornblende, and particularly with hexagonal plates of black mica, by which, and by the abſence of olivine and augite, it is diſtinguiſhed from decompoſing baſalt.

Baſaltic Tufa is the reſult of the decompoſition or rather of the diſintegration of certain beds of baſalt; it conſiſts of pieces of baſalt, fragments of olivine, and vegetable remains agglutinated together by an argillaceous cement.

Secondary amygdaloid, appears to have for a baſe decompoſed grunſtein, which is often penetrated by ſiliceous particles; ſometimes it paſſes into wakke and ſometimes into baſalt. The ſpheroidal cavities of this amygdaloid are either empty or filled with green earth, zeolite, calcareous ſpar, chalcedony, &c.

Klingſtein porphyry conſiſts of a baſe of Klingſtein in which are imbedded cryſtals of felſpar, and ſometimes of hornblende. It paſſes frequently into baſalt.

Secondary grunſtein, like the primitive and tranſition grünſtein is compoſed of hornblende and felſpar, but in this the grains have a leſs perfect cryſtalline appearance.

Grauſtein, or grey ſtone, is a rock compoſed of very minute grains of hornblende and felſpar in a ſtate of ſuch intimate mixture, as to have the appearance of an almoſt uniform maſs of an aſh-grey colour. It contains olivine and augite.

The proper baſe to the ſecondary trap formation, or in other words the ſubſtance which appears to have immediately preceded it in the order of formation, is ſecondary limeſtone; it is however not unfrequently found reſting on ſandſtone, on argillite, on gneiſs, and even on granite.

The general order in which the ſtrata of this formation are arranged relatively to each other, is the following, viz. coarſe ſand, fine ſand, ſandy clay, unctuous clay, wakke, baſalt, amygdaloid, klingſtein porphyry, grünſtein, and grauſtein; it hardly ever happens however that all theſe ſtrata are met with in the ſame maſs of mountain.

No metallic veins are found in this claſs of mountains, but the remains of vegetable and marine organized bodies are of frequent occurrence.

TREMOLITE. *Tremolith*, Wern. Broch. *Grammatite*, Hauy.

Of this mineral there are the three following ſubſpecies.

1 *Subſp.* Common Tremolite.

Its colour is greeniſh-white, ſometimes greyiſh, reddiſh or yellowiſh-white, alſo pearl-grey, ſmoak-grey, and pale browniſh green. It occurs in maſs or cryſtallized. Its primitive form is that of an oblique rhomboidal priſm, the alternate angles of which are 127° and 53°. It alſo preſents the following varieties.

1. The primitive tetrahedral priſm with dihedral ſummits. Each ſummit is compoſed of two iſoſceles triangles joined by their baſes, having their apexes adjacent to the acute angles of the priſm.

2. The preceding with the acute edges of the priſm truncated, whence reſults a hexahedral priſm, with the terminal triangles, compoſing the ſummit, alſo truncated at their apexes, or in other words converted into trapeziums.

3. The ſame as var. 1, with both the acute and obtuſe edges of the priſm truncated, whence reſults an eight-ſided priſm with dihedral ſummits, the planes of which are triangles with all their angles truncated, or hexagons.

The cryſtals are middle-ſized, longitudinally ſtriated, confuſedly grouped together, and imbedded; internally, tremolite is gliſtening or ſhining, with a pearly luſtre. Its fracture is broad ſtriated with parallel or divergent rays, and paſſes into foliated. Its croſs fracture is uneven. It preſents granular or wedge-ſhaped diſtinct concretions. It is tranſlucent, when cryſtallized ſemi-tranſparent; is generally hard enough to ſcratch glaſs, is brittle, and eaſily frangible.

2 *Subſp.* Glaſſy Tremolite.

Its colour is greyiſh and yellowiſh-white, rarely greeniſh or reddiſh. It occurs in maſs, or in elongated needle-ſhape cryſtals. Internally it is more or leſs ſhining with a pearly luſtre. Its longitudinal fracture is divergingly radiated paſſing into fibrous; its croſs fracture is uneven. It is compoſed of priſmatic diſtinct concretions the ſurfaces of which are ſlightly ſtriated. It is tranſlucent, moderately hard, brittle, and eaſily frangible.

It melts before the blowpipe without addition into a white ſcoria. Its component parts, according to an analyſis by Klaproth, are

65.	Silex
10.33	Magneſia
18.	Lime
0.16	Oxyd of iron
6.5	Water and carbonic acid
99.99	

3 *Subſp.* Aſbeſtous Tremolite.

Its colour is yellowiſh, reddiſh, greeniſh, or greyiſh white. It occurs in maſs and in capillary cryſtals. Its internal luſtre is gliſtening and pearly. Its fracture is ſtrait and fine fibrous either ſimply divergent or bundled. It preſents granular and wedge-ſhaped diſtinct concretions. It is tranſlucent on the edges, is ſoft and eaſily frangible.

The ſofter varieties of tremolite are phoſphoreſcent both by heat and by friction.

Tremolite was firſt diſcovered by Pini in the valley of Tremola among the Italian Alps. It alſo occurs in Mont St. Gothard in Switzerland, in the Tyrol, Tranſylvania, Moravia, and at Langenfeldt in Saxony; alſo in Siberia near Lake Baikal, in the Shetland iſlands, and in the caſtle rock of Edinburgh.

It occurs principally in primitive mountains, imbedded in dolomite or granular limeſtone, and mixed with mica and talc. It is alſo found in the ſecondary trap-formation, accompanied by prehnite.

TRIPHANE. *Spodumene*, D'Andrada and Werner.

Its colour is apple-green, or greeniſh-white. It occurs in maſs. Its longitudinal fracture is ſhining; its croſs fracture is gliſtening, with a pearly luſtre. Its fracture is foliated in two directions; the croſs fracture is fine grained uneven. The fragments are indeterminate, or in the form of very oblique rhombs. It is tranſlucent, moderately hard, and eaſily frangible. Sp. gr. 3.21.

Before the blowpipe it becomes yellow and ſplits into thin plates, and then melts into a tranſparent greyiſh glaſs.

It has hitherto been found only in the mines of Uton, near Dalero in Sweden, in veins with quartz and back mica.

TRIPOLI. *Trippel*, Wern.

Its colour is yellowiſh-grey, paſſing into aſh-grey and reddiſh-brown. It occurs in maſs, and is without luſtre; its fracture is coarſe-grained earthy, paſſing into obſcurely ſlaty. It is ſoft, often friable; is meagre and rough to the touch, and does not adhere to the tongue.

It is ſcarcely fuſible before the blowpipe without the aſſiſtance of borax. It is compoſed, according to M. Haaſe, of

90	Silex
7	Alumine
3	Oxyd of iron
100	

It was formerly brought to Europe from Tripoli in Africa, but has ſince been found in Saxony, at Pottſchappel near Dreſden, in Derbyſhire, in Flanders, Switzerland, Heſſe, Weſtphalia and Ruſſia. It occurs in veins and beds in ſecondary rocks, and probably ſometimes is a pſeudo-volcanic production.

It is largely employed in poliſhing metals, marble, glaſs, and other hard bodies.

TUBE OF SAFETY.

An article of chemical apparatus, for an account of which ſee the Appendix.

TUFA calcareous. *Kalk Tuff*, Wern.

Its colour is yellowiſh-grey or ſmoke-grey. It occurs ſometimes ſolid, but generally porous and marked with impreſſions of reeds, moſs, and other vegetables. Its luſtre, when it has any, is faintly glimmering. Its fracture is fine grained uneven, paſſing into earthy. It is ſoft, eaſily frangible, and not much heavier than water.

It efferveſces with acids, and is little elſe than carbonat of lime.

It occurs in alluvial land, being depoſited by water impregnated with carbonat of lime.

The more compact kinds are employed in building, for which their lightneſs well adapts them.

TUNGSTEN. *Scheelium.*

Tungſten is a hard brittle granular metal, very difficultly ſoluble in the acids, combines with the alkalies, and is converted from yellow to blue oxyd by muriated tin.

§. 1. *Ores.*

Sp. 1. Tungsten. *Schwerſtein*, Wern.—*Scheelin calcaire*, Hauy. *Goſſan*, of the Corniſh miners.

Its colour is greyiſh or yellowiſh-white, paſſing into yellowiſh-grey; it is often ſuperficially tarniſhed to dark pearl-grey or yellowiſh brown. It occurs in maſs, diſſeminated, and cryſtallized. Its primitive form, according to Hauy, is the cube; but the uſual form that it preſents is the octohedron, either regular, or bevilled at the common baſe of the pyramids, or cuneiform. Its cryſtals are middle-ſized or ſmall. The lateral planes of the cryſtals are ſmooth and brightly ſhining with a nearly adamantine luſtre. Its fracture is imperfectly foliated, paſſing into conchoidal and uneven; that of the maſſive varieties is granular and ſplintery. It ſometimes occurs in large or ſmall grained diſtinct concretions. The cryſtallized is tranſlucent, rarely tranſparent; the maſſive is opake. It may be ſcraped without difficulty by a knife, is eaſily frangible, but not particularly brittle. Sp. gr. 6.01. = 5.57.

Before the blowpipe, without addition, it crackles and becomes opake, but is not fuſible. When pulverized and digeſted with nitric or muriatic acid it leaves a lemon-yellow reſidue, which is tunſtic oxyd. This mineral has been analyſed, firſt by Scheele, then by the Elhuyars, and laſtly by Klaproth, with the following reſults.

From Bitſberg. By Scheele.	Schlackenwald. Elhuyars.	Schlackenwald. Klaproth.	Cornwall. Klapr.	
65.	68.	77.75	75.25	Oxyd of Tungſten.
31.	30.	17.6	18.7	Lime.
4.	0.	3.	1.5	Silex.
			1.25	Oxyd of Iron.
			0.75	Ditto of Manganeſe.
100.	98.	98.35	97.45	

Tungſten is rather a rare mineral. It occurs in metallic veins in primitive mountains, accompanied by tinſtone, hæmatite, wolfram, quartz, mica, ſteatite, &c. It is found at Bitſberg in Sweden, Schlackenwald in Bohemia, and Pengilly in Cornwall.

Sp. 2. **Wolfram.** *Wolfram*, Wern. Broch. *Schéelin ferrugine*, Hauy.

Its colour is browniſh-black, greyiſh-black, and dark reddiſh-brown, often with a greeniſh irideſcent tarniſh. It occurs maſſive and cryſtallized. Its primitive form is a rectangular parallelopiped; beſides which it preſents the following varieties:

1. A tetrahedral priſm, with dihedral ſummits, with the common edges of the ſummits and priſm truncated.

2. A compreſſed tetrahedral priſm, with bevilled dihedral ſummits, obliquely truncated.

3. The ſame, with the lateral edges of the priſm alſo bevilled.

The cryſtals are of middle-ſize or large, ſometimes ſolitary, but moſt commonly grouped together in an irregular manner, and often very indiſtinct. Externally they are gliſtening, internally they are brightly ſhining with a metallic luſtre. Its longitudinal fracture is ſtrait lamellar, its croſs fracture is granular uneven. It occurs ſometimes in curved lamellar diſtinct concretions, with alternate ſaliant and re-entering angles. It is opake, gives a reddiſh-brown powder, may be readily ſcraped with a knife, is brittle and eaſily frangible. Sp. gr. 7.12.

Before the blowpipe it crackles and becomes of a darker colour, but does not melt. It has been analyſed by the Elhuyars, by Wiegleb, by Klaproth, and by Vauquelin, with the following reſults:

Elhuy.	Wiegl.	Klapr.	Vauq.	
65.	35.75	46.9	67.	Yellow oxyd of Tungſten.
22.	32.	0.	6.25	Oxyd of Manganeſe.
13.5	11.	31.2	18.	Oxyd of Iron.
2.0	0.	0.	1.5	Silex.
102.5	78.75	78.1	92.75	
	21.25	21.9	7.25	Loſs

It occurs in veins in primitive mountains, generally accompanied by tinſtone. It is found at Zinnwald, Graupen, and Schlackenwald, in Bohemia; at Ehrenfriedersdorf, Geyer, and Altenſberg in Saxony; at St. Leonard, departement de la Haute Vienne in France; Poldice in Cornwall.

§. 2. *Aſſay and Analyſis.*

1. The analyſis of tungſten is very ſimple; the moſt ſucceſsful method of performing it is that which was invented by Scheele,[a] and has ſince been adopted by Klaproth,[b] viz. After the mineral has been finely pulverized, let it be digeſted in moderately ſtrong nitric acid, by which a part will be diſſolved, and the reſidue will acquire a yellow colour; then pour off the nitric ſolution, edulcorate the reſidue, and afterwards digeſt it in liquid ammonia. This latter menſtruum will take up a portion and change the colour of the remainder to white: proceed in this manner, alternately employing nitric acid and ammonia, till every thing ſoluble is taken up; what remains is generally nothing but a ſmall quantity of *ſilex*.

The nitric ſolution is now to be treated with liquid cauſtic ammonia, by which any oxyd of *iron* or *manganeſe* that may be preſent will be thrown down; which being ſeparated by the filter, carbonat of ſoda is to be added to the ſolution in order to precipitate the *lime:* this, when waſhed and dried, is pure carbonat, from which the amount of pure lime may be deduced by the common rule of proportion.

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[a] Eſſays.

[b] Analyt. Eſſ. vol. ii. p. 33.

The ammoniacal ſolution contains only ammonia and oxyd of tungſten; it is therefore to be evaporated to dryneſs, and the reſidue gently ignited in a platina crucible; by this proceſs the ammonia will be deſtroyed and driven off, and a pure yellow oxyd of *tungsten* will be left behind.

2. The analyſis of Wolfram is to be conducted nearly in the ſame manner as the preceding. Having reduced the ore to fine powder, it is to be digeſted with nitro-muriatic acid; a pretty copious diſengagement of nitrous gas will enſue, part of the powder will be diſſolved, and the remainder will be of a yellowiſh colour: the nitro-muriatic ſolution being poured off, the reſidue is to be treated with liquid ammonia; thus alternately making uſe of theſe two menſtrua till nothing but a few grains of quartz remains behind.

The muriatic ſolution, containing the oxyds of iron and mangancſe, is to be mixed with perfectly neutralized carbonat of potaſh, till the liquor begins to grow turbid; being then gently boiled for a minute or two, a copious precipitation of oxyd of iron will take place. The clear liquor being then neutralized with a ſolution of pearlaſh, will depoſit a cream-coloured precipitate, conſiſting of carbonated mangancſe, with a little oxyd of iron, which is to be ſeparated as already deſcribed in the article MANGANESE.

The ammoniacal ſolution contains the oxyd of tungſten, which may be procured in the form of a yellow powder, by evaporating to dryneſs and ſubſequent ignition in a platina crucible.

3. It remains to make a few remarks on the particulars of the analyſes quoted in the preceding ſection.

The analyſes of tungſten by Scheele and the Elhuyars agree very nearly with each other, though they differ very widely from thoſe by Klaproth. It is to be obſerved however that the analyſis attributed to Scheele is merely an inference from a ſingle experiment, in which 80 grains of tungſten were alternately treated with nitric acid and ammonia; the nitric ſolution, when ſaturated by carbonated potaſh, afforded 45 grs. of carbonat of lime; but no mention is made of the proportion of tungſten contained in the ammoniacal ſolution. The particulars of the analyſis by the Elhuyars we have not ſeen; but thoſe by Klaproth are ſtated at length in his Analytical Eſſays, and appear to be liable to no objections.

With regard to the four analyſes of Wolfram, it is remarkable that in thoſe by Wiegleb and Klaproth there is a deficiency amounting to between 21 and 22 per cent. The particulars of theſe two analyſes we have not been able to meet with, and therefore can only account for the deficiency by ſuppoſing that the old method of decompoſing this ſubſtance by fuſion with nitre or fixed alkali has been reſorted to; in which caſe the oxyd of tungſten being rendered ſoluble in water by combination with alkali and the precipitating acid, may have partly eſcaped in the waſhings.

The method employed by Vauquelin[c] and the Elhuyars[d] was the alternate application of muriatic acid and liquid ammonia, and the following was the *ſtate* in which the component parts were eſtimated, viz. yellow oxyd of tungſten, magnetic oxyd of iron, and black oxyd of mangancſe. But though theſe metals were obtained from the ore at the above-mentioned ſtates of oxydation, it does by no means follow that they exiſted in this ſtate in the ore itſelf. Firſt with regard to the iron; this it is evident does not exiſt in the Wolfram as black oxyd; for the mineral is wholly incapable of affecting the magnetic needle. Secondly, with regard to the manganeſe; this probably exiſts in the wolfram at a low ſtate of oxydation, for when digeſted with muriatic acid there is no perceptible odour of oxy-muriatic acid, and its colour is very conſiderably deepened by gentle calcination. Thirdly, with regard to the tungſten; in the analyſes both of Vauquelin and the Elhuyars it is mentioned, that the colour of the reſidue after digeſting wolfram with muriatic acid, was yellow; from which it would appear that the tungſten exiſted in the ſtate of yellow oxyd in the ore. It is with the utmoſt diffidence that we oppoſe our own experiments to thoſe of ſo accurate and able a chemiſt as Vauquelin, yet as they were carefully made we cannot avoid ſtating them. The wolfram that we operated on was from Cornwall, and of a dark liver colour. When digeſted with nitro-muriatic acid, there was a copious production of nitrous gas, the liquor became of a high wine colour, and had taken up oxyd of iron and manganeſe, but nothing elſe. The reſidue conſiſted of undecompoſed wolfram, mixed with a yellow powder, which laſt was entirely taken up by liquid ammonia. On the other hand, when ſtrong and very pure muriatic acid was employed, the liquor acquired a browniſh green colour, no oxy-muriatic acid gas was given out, and the ſolution, beſides iron and manganeſe, contained oxyd of tungſten, which was thrown down by the addition of diſtilled water, in the form of a pale yellowiſh green powder; this powder was not reſoluble in muriatic acid; it became white on the addition of ammonia, but was very ſparingly ſoluble. Its greeniſh tinge was changed to bright yellow by nitric acid, nitrous gas being diſengaged. The decompoſed reſidue of the ore not taken up by muriatic acid, was of a dirty green colour, but on the addition of ammonia became of a deep blue, which blue powder was inſoluble in ammonia. We cannot therefore but conclude that the acid employed by Vauquelin was mixed with nitric acid; and that the tungſten exiſts in wolfram in the ſtate of blue ſub-oxyd.

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[c] Journ. des Mines, No. 19. p. 17.

[d] Chemical analyſis of Wolfram, &c. by the Elhuyars, tranſlated by C. Cullen, p. 30.

§. 3. *Reduction of ores.*

Metallic tungſten not being applied to any uſe, the only attempts to reduce it have been made on ſmall quantities in the laboratory. The Elhuyars were the firſt who obtained it in the reguline ſtate.[e] For this purpoſe they put 100 grains of the yellow oxyd into a crucible lined with charcoal, and gave it a ſtrong heat for an hour and a half. The crucible was broken when cold, and was found to contain a friable congeries of metallic globules, of the colour and luſtre of ſteel, and weighing 60 grs. Vauquelin[f] afterwards repeated the experiment, by firſt mixing the yellow oxyd with oil, and then expoſing it in a lined crucible for two hours to the violent heat of a forge furnace: he obtained a darkiſh grey maſs, conſiſting of a number of ſmall globules. In another experiment, where the oxyd and oil was mixed with boracic acid, he obtained a porous maſs of a greyiſh white colour, with the cavities lined with minute, brilliant, metallic cryſtals. A third method has been practiſed with ſucceſs by the writer of this article, aſſiſted by Mr. Allen. 240 grs. of tunſtat of ammonia, in acicular cryſtals, were put into a crucible lined with charcoal, and expoſed for two hours to a powerful wind furnace; there was thus produced a ſlightly cohering maſs, weighing 161 grs. of roundiſh grains, about the ſize of a pin's head, with a very brilliant metallic luſtre.

§. 4. *Phyſical and Chemical properties.*

The colour of tungſten is a light ſteel-grey, with a brilliant metallic luſtre: it is in the form of minute grains, ſlightly agglutinated; it is very hard, yielding with difficulty to the file. Its ſp. gr. according to the Elhuyars, is = 17.6, according to an experiment of my own is = 17.33. It does not at all affect the magnetic needle: when expoſed to a ſtream of oxygen gas on charcoal it burns with a yellow flame without melting, and is entirely volatilized in the form of a thick vapour, which when collected is the yellow oxyd of this metal.

Neither the muriatic nor ſulphuric acids have any perceptible action on this metal, even at a boiling heat; but when mixed with a little nitric acid, a diſengagement of nitrous gas enſues, and the metal is partly diſſolved, and partly diffuſed through the liquor in the ſtate of yellow oxyd. This ſolution undergoes no change on dilution with water; by the addition of a few drops of pruſſiat of potaſh, its colour becomes a deep ſomewhat irideſcent green, but no precipitation takes place; by cauſtic potaſh it is changed to a brown olive, and the green colour is again reſtored by the addition of a few drops of nitric acid.

By a red heat, with acceſs of air, tungſten is readily converted into a lemon yellow oxyd: 100 parts of the metal afford, according to the Elhuyars, 124 of oxyd.

The above are all the facts hitherto publiſhed concerning metallic tungſten, thoſe which follow being the reſults of experiments made on the oxyd of this metal, as extracted from its ores, without having been ſubſequently reduced to the reguline ſtate.

There are two oxyds of tungſten, the yellow or per-oxyd, and the blue or ſub-oxyd. The former may be prepared in various ways; firſt, as already mentioned, by calcination of the metal; ſecondly, by fuſing two parts of wolfram with three of nitre, and digeſting the ſaline maſs thus produced in hot water; the liquor contains the oxyd of tungſten combined with potaſh, and holding in ſolution a little oxyd of manganeſe: by expoſure to the air for a day or two, the latter oxyd is precipitated; the clear liquor being then evaporated to dryneſs is to be digeſted with three or four ſucceſſive portions of nitric acid, by which the alkali will be taken up, and the yellow oxyd of tungſten will remain behind, ſtill however combined, perhaps, with a little alkali. A third method, and upon the whole the beſt, of preparing this oxyd, is by calcining the cryſtallized tunſtat of ammonia in an open crucible of platina, by which the alkali will be entirely driven off and deſtroyed, and perfectly pure oxyd will remain behind: 100 parts of this ſalt afford, according to Vauquelin, 78 of yellow oxyd.

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[e] Chemical analyſis of Wolfram, &c. p. 58.

[f] Journ. des Mines, No 19, p. 24.

The proportion of oxygen in the yellow oxyd has not yet been aſcertained with much preciſion. The Elhuyars obtained from 100 parts of oxyd 60 parts of metal, according to which the oxyd contains 40 per cent. of oxygen; but on the other hand, from 100 parts of metal they obtained by calcination only 124 parts of oxyd, which would make the oxyd contain only 19.4 per cent. of oxygen. This latter proportion appears the moſt worthy of credit, both from the circumſtances of the experiment, and becauſe it does not very much differ from the proportions obtained by combining the reſults of two other experiments, the one by Vauquelin and the other by myſelf, according to which 100 parts of tunſtat of ammonia afford 78 of yellow oxyd, and 240 parts of the ſame ſalt afford 161 of metal, which would give for the compoſition of the yellow oxyd 86 parts of metal to 14 of oxygen.

The yellow oxyd is inſipid and inodorous: its ſp. gr. is = 6.12. When expoſed to the blowpipe in a platina ſpoon, it acquires a deep green colour; it gives a deep blue when fuſed with microcoſmic ſalt; when heated on charcoal it becomes of a dark bluiſh black. By a ſtrong heat in a cloſe crucible its colour is changed to a blackiſh grey, according to Vauquelin; but according to the Elhuyars it forms a ſpungy maſs of a bluiſh black colour, and covered ſuperficially with minute cryſtals; its ſp. gr. is increaſed to 9.55, and by calcination in a muffle it again acquires a yellow colour, and its weight is increaſed by 2 per cent. (It is to be obſerved however, that the oxyd employed by the laſt mentioned chemiſts was prepared according to the ſecond of the methods above deſcribed, and therefore might poſſibly contain a little potaſh). The yellow oxyd when digeſted with a little dilute muriat of tin, acquires a deep blue colour, and if in this ſtate it is removed into dilute nitric acid and warmed, nitrous gas will be given out, and the yellow colour will be again reſtored, thus clearly ſhowing that the blue powder is the ſub-oxyd of this metal.

The yellow oxyd even if diſtilled repeatedly to dryneſs with nitric acid, undergoes no apparent alteration. It is entirely inſoluble in water, but if rubbed in a mortar with this fluid it forms a yellow emulſion, which paſſes turbid through the pores of filtering paper, and requires very long reſt before it becomes clear. This yellow fluid has no taſte, nor does it at all redden litmus or other blue vegetable ſubſtances; it may therefore be queſtioned how far it has a title to its uſual appellation, tunſtic acid, (the tunſtic acid of Scheele being a very different ſubſtance, as we ſhall ſhow preſently), as, however it unites with the alkalies, and diſlodges carbonic acid from ſome of its combinations, it may without impropriety be conſidered as at leaſt acting the part of an acid.

The yellow oxyd is entirely inſoluble in the ſulphuric, nitric, or muriatic acids; by digeſtion with acetous acid it is converted into the blue oxyd, but is not diſſolved. Cauſtic potaſh either in the dry or moiſt way combines with the yellow oxyd, forming a ſalt with exceſs of alkali, readily ſoluble in water, from which by evaporation may be obtained a glittering powder, but without any appearance or regular cryſtallization. *Tunſtat of Potaſh* thus obtained has a ſomewhat cauſtic metallic taſte, is deliqueſcent in a moiſt air, and is eaſily ſoluble in water. When ſuperſaturated with nitric acid a white precipitate falls down, which, when waſhed with cold water and dried, preſents the following properties[g]. It is acid to the taſte, colours litmus red, and is ſoluble in about 20 parts of boiling water. The ſolution when mixed with lime water, and boiled, depoſits a heavy white powder which appears to be tunſtat of lime. When ſaturated with an alkali it yields by evaporation a cryſtalline ſalt. When boiled with filings of zinc, tin, or iron, the liquor becomes of a deep blue, and depoſits a precipitate of the ſame colour. Nitric or muriatic acid when boiled on the above mentioned white precipitate, change its colour to yellow, as ſulphuric acid does to blue. From the above properties it was conſidered by Scheele as the pure acid of tungſten, but later experiments have proved that this was a miſtake, it being a triple ſalt compoſed of oxyd of tungſten, potaſh, and nitric acid. The compoſition of this ſalt is ſatisfactorily ſhewn by an experiment of the Elhuyars.

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[g] Scheele's Eſſ.

To a ſolution of it in water was added lime-water as long as any precipitation enſued: the precipitate being waſhed and dried, was found to be pure tunſtat of lime: the reſidual liquor being then evaporated, afforded on cooling, cryſtals of nitre.

Tunſtat of potaſh is decompoſable by every other acid as well as by the nitric, and the white precipitate is in all theſe caſes a triple ſalt, compoſed of potaſh, oxyd of tungſten, and the precipitating acid.

If the yellow oxyd of tungſten is digeſted with carbonated inſtead of cauſtic potaſh, an effervefcence is produced by the diſengagement of carbonic acid, and the reſulting tunſtat of potaſh is the ſame as that already deſcribed.

Tunſtat of ſoda is produced by digeſting the yellow oxyd with cauſtic or carbonated ſoda, and evaporating the liquor, which depoſits the ſalt in queſtion in the form of lengthened hexahedral plates. The taſte of this ſalt is acrid and metallic; it changes the colour of red vegetable infuſions as the alkalies do: it is ſoluble in four times its weight of cold, and in twice its weight of boiling water: it is decompoſable by the acids forming with them triple ſalts analogous to thoſe of tunſtat of potaſh: the phoſphoric acid however occaſions no precipitate, forming with it a very ſoluble triple ſalt, which is not decompoſed even by ſulphuric acid.

Tunſtat of ſoda is not rendered turbid by the ſulphats either of potaſh or of magneſia; but alum and the muriats of lime and barytes throw down a white precipitate: alkaline pruſſiat of potaſh occaſions no turbidneſs in this ſalt, but on the addition of a little muriatic acid a brown precipitate falls down, which is ſoluble in a large proportion of water. Neither the ſulphuret of ammonia, nor ſolutions of oxyd of arſenic or corroſive muriat of mercury occaſion any precipitate; the latter ſubſtance however changes the colour of the ſolution to yellow. With ſulphat of iron there is formed a brown precipitate, which by digeſtion in muriatic acid is decompoſed, the oxyd of iron being taken up, and yellow oxyd of tungſten remaining behind. Tincture of galls, when mixed with tunſtat of ſoda, occaſions an abundant flocculent precipitate ſtraw of a pale colour.

Ammonia combines readily with the yellow oxyd, forming *tunſtat of ammonia*; which cryſtallizes from its ſolution, by evaporation and cooling, in the form of ſhining plates like boracic acid, or in ſlender tetrahedral priſms. Its colour is very pale yellowiſh brown. It has a metallic taſte, is ſoluble in water, is not deliqueſcent, and exhibits with the various reagents analogous properties to thoſe of the preceding ſalts. By a red heat the ammonia is totally decompoſed; leaving the tungſten behind in the ſtate of yellow or blue oxyd, according as the proceſs has been performed in an open crucible or in a retort.

The only uſe that has hitherto been ſuggeſted of tungſten in any form, is as a mordant. The triple acidulous tunſtat when digeſted, according to Morveau,[h] with the red juices of fruits, and with infuſions of turmeric and tourneſol, forms with them coloured lakes of remarkable fixity, and hence may be of conſiderable uſe in the arts. Theſe experiments, however, on repetition in this country, have not been attended with the ſucceſs that would naturally be expected from the repreſentations in the memoir referred to.

TURBITH MINERAL. See MERCURY.

TURF. See PEAT.

TURMERIC. *Terra Merita.* (*Curcuma longa*, Linn.)

The root of the turmeric, which is cultivated largely in the Eaſt Indies, conſiſts of a large oval bulb, from which ſpring two or three tortuous proceſſes three or four inches long. This root is of a duſky brown externally, and of a deep orange yellow within, of a ſomewhat fragrant ſmell, and a bitteriſh aromatic taſte. The yellow colour is extracted eaſily, both by water and alcohol, and is ſometimes uſed in dyeing, but the dye is extremely fugitive, and cannot be fixed on cloth by any known mordant, which is a loſs to the dyer as there is no vegetable ſubſtance that gives ſuch a rich orange yellow. When employed in dyeing it is chiefly to give a finiſhing gloſs to the more ſolid colours, which ſoon fades. The yellow of tumeric is rendered ſomewhat paler by acids, but is changed to a brick-red by the alkalies and alkaline earths, and it is the latter property that renders it of uſe to the chemiſt, as its ſenſibility to alkaline teſts is ſo great as to indicate a ſmaller quantity of theſe ſubſtances than can be done by any other method, and hence the exact point of ſaturation may be hit, which is of importance in many experiments of reſearch. To apply it, either a ſpirituous tincture or a watery infuſion may be uſed, or more ſimply, a freſh-cut ſurface of the entire root may be wetted with diſtilled water, and by being rubbed on white paper, a very viſible yellow mark will be made, on which a drop of the liquor to be examined may be dropped. When the quantity of alkali is very ſmall, it requires a few minutes to produce the full change.

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[h] An. de Chim, vol. xxx. p. 123.

Tumeric is uſed largely in the Eaſt as a condiment to food, and in particular, it is the ſubſtance that gives the colour to curry.

TURNSOLE. See LITMUS.

TURPENTINE, *and other reſinous products of the Pine.*

Under this head we ſhall deſcribe the methods of procuring and preparing a variety of very important articles[a] of commerce, ſuch as turpentine, reſin, pitch, tar, &c. which are employed ſo extenſively in ſhip-building and rigging, in varniſhes, and many other purpoſes of inferior intereſt.

All theſe are the products of one or other ſpecies of pine, and ſometimes the ſame ſubſtance is yielded by different ſpecies, as all the varieties of the native reſin, or turpentine, have a very great reſemblance in chemical properties.

There are three varieties of pine turpentine, commonly known under that name in Europe; namely, 1ſt. *the common turpentine*, obtained chiefly from the *Pinus Sylveſtris* (Scotch Fir). 2d. *the Strasburgh turpentine* yielded by the *Pinus Picea* (Silver Fir) and 3d. the *Venice turpentine* procured from the *Pinus Larix* (Larch). To theſe may be added two liquid turpentines. 4th. *the Carpathian or Hungary Balſam*, which exſudes from the *Pinus Cembra* (Siberian Stone Pine). 5th. *the Canada Balſam*, the reſinous juice of the *Pinus Balſamea* (Balm of Gilead Fir). The fine fragrant *Chio turpentine* is not procured from a pine, but from a low ſhrub (the *Piſtacia Lentiſcus*) which will be deſcribed in the next article.

Of the three firſt-mentioned turpentines, the *Venice* is the thinneſt and moſt aromatic, the *Straſburg* the next in theſe qualities, and the *Common* is the firmeſt and coarſeſt. The two former are often adulterated by a mixture of the common turpentine and oil of turpentine, and it is to be obſerved that the terms Venice and Straſburg turpentine are not now appropriate, as they are procured from various countries.

Common turpentine is obtained largely in the pine foreſts in the ſouth of France, in Switzerland, in the countries on the north of the Pyrenees, in Germany, and in many of the ſouthern ſtates of North America. The greater part of what is conſumed in this country is imported from North America. The method of obtaining it is by making a ſeries of inciſions through the bark of the tree, from which the turpentine exſudes, and falls down into holes or other receptacles at the foot. The proceſs is deſcribed very accurately by Duhamel and Moringlane as practiſed in the ſouth of France.

The fir is generally allowed to remain untouched till it is thirty or forty years old. When it is to be worked, which is early in the ſpring, a ſmall hole is firſt made in the ground at the foot of the tree, the earth of which is well rammed, and ſerves as a receptacle for the juice. The coarſe bark is then ſtripped off from the tree, a little above the hole down to the ſmooth inner bark, after which a portion of the inner bark together with a little of the wood is cut out with a very ſharp tool, ſo that there may be a wound in the tree about three inches ſquare, and an inch deep. Immediately afterwards the turpentine begins to exſude in very tranſparent drops, which eſcape chiefly from the wood immediately under the inner bark. The hotter the weather is, the greater is the ſupply of reſin, and to facilitate the ſupply the inciſions are enlarged every three or four days by cutting off thin ſlices, till at the end of the year it is about a foot and a half wide and two or three inches deep. The whole time during which the turpentine flows is from the end of February to October. In the winter it entirely ceaſes, but in the enſuing ſpring a freſh inciſion is begun a little above the former, and managed in the ſame manner. This practice is continued annually for about twelve or fifteen years in ſome parts, and in others a ſhorter time, on the ſame ſide of the tree, till the later inciſions are ſo high as to be out of reach without the aſſiſtance of ſteps; after which the contrary ſide of the tree is begun upon, and worked in a ſimilar manner for as many years, during which time the firſt inciſions are grown up, and are fit to be cut afreſh. In this way, a healthy tree in a favourable ſoil, may be made to yield from ſix to twelve or more pounds of turpentine annually, ſometimes for a century, and even the timber is not ſoon injured by this conſtant drain.

The flow of turpentine diſcontinues altogether about October, and the liquid reſin collected during the year from each tree, is put together for further purification. But a conſiderable quantity of the reſin has concreted during that time around the inciſion, particularly as the heat declines; and in the winter when it has hardened conſiderably it is ſcraped off, and forms what is technically called *Barras*, or in ſome provinces *Galipot*, which differs from the more liquid turpentine in conſiſtence, and probably contains a leſs proportion of eſſential oil. The galipot is much uſed in making flambeaux when mixed with ſuet, but the greater part of it, as well as the liquid turpentine, is ſubjected to further proceſſes.

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[a] Dr. Matons Supplement to Lambert on the Genus Pinus. Moringlane in the Journ. de Phyſ. tom. 31. Murray's Apparatus Medicam. Dict. d'Hiſt. Nat. Article GOUDRON, &c. &c.

Theſe we ſhall reſume when we have deſcribed the method of obtaining the other kinds of turpentine, which however, is ſo very ſimilar that a few words will ſuffice.

The *Straſburgh Turpentine*, the produce of the ſilver fir, is the moſt fragrant of all the pine turpentines, and only inferior to the true Chio, but it is not often ſeen in the ſhops. It is obtained by rude inciſion of the bark by the peaſants in the vaſt pine foreſts on the weſtern Alps. The firſt cut is made as high as the hatchet will reach, and theſe are renewed annually from above downwards to within a foot of the ground. But the fineſt kind of turpentine yielded by this tree, is that which exſudes from ſoft tubercles or ſwellings of the inner bark. The peaſants carry with them a large cow's horn, with the point of which they pierce theſe tubercles, and collect the juice in its hollow. Only a few drops are yielded from each tubercle, ſo that this turpentine is rare and bears a higher price. It is called technically *Bigoin* or *Oil of Pine*, and when thickened by expoſure to the air, it remains clear like maſtich, whereas the turpentine obtained from the ſame tree by inciſion of the bark becomes white and opake by age.

The true *Venice turpentine*, or reſin of the Larch, is obtained from the Tyrol and Savoy, and alſo from Dauphiny, by boring holes about an inch in diameter, with a gentle deſcent, in the moſt knotty parts of the tree. To theſe are adapted long perforated pegs, which ſerve as gutters to convey the juice into troughs placed beneath. It is yielded during the whole of the ſummer, and is ſimply purified by ſtraining through hair ſieves. A full-grown larch will ſometimes yield ſeven or eight pounds of turpentine annually for forty or fifty years.

Much of the Venice turpentine of the ſhops is brought from America, and it is doubtful from what tree it is procured. This turpentine hardly becomes ſolid by any length of keeping.

The Carpathian, or Hungary Balſam, is obtained from the Stone Pine in Hungary and the Tyrol, either by breaking off the twigs of the tree, and collecting in a glaſs the fine reſin that exſudes; or by boiling the ends of the freſh boughs in water, when the balſam riſes to the top. The former method yields by far the beſt. This is a whitiſh, pellucid, and very fluid turpentine, which does not harden by keeping.

The Canada Balſam is a tranſparent whitiſh juice, of the conſiſtence of Copaiva balſam, and of a very fragrant ſmell and bitteriſh taſte, obtained from the Balm of Gilead Fir, and imported from Canada, but the mode of collection is not well known.

To return to the various operations performed upon the common turpentine, which as above mentioned is obtained in two degrees of liquidity, the moſt fluid being called properly turpentine, and the leaſt fluid having the name of *barras* or *galipot* in the South of France, whence it is procured.

The turpentine contains a number of impurities entangled in its ſubſtance, from which it is purified in two methods. One of them is to incloſe it in a caſk perforated at bottom, and by expoſure to a hot ſun it becomes ſo fluid as to filter through, which gives the fineſt and moſt valued turpentine. The other method is to heat it moderately in a large copper, till it is quite liquid, and then to filter it through a ſtrainer made of rows of ſtraws laid cloſe to each other. This gives it a golden colour.

The harder turpentine, or *Barras*, is alſo purified in the latter mode, but inſtead of being merely liquefied in the copper, the heat is continued for ſome time, till part of the eſſential oil is ſo far diſſipated that a little of it cooled on a piece of wood may be cruſhed to powder by the fingers. It is then ſtrained through ſtraw while hot, and the pure reſin on cooling hardens into a yellow opake maſs which is called *Brai-ſec* or *Raſe*. This is ſometimes ſold as *Burgundy pitch*, which however appears to be properly the product of another ſpecies of pine, as we ſhall preſently mention. This opake yellow brown reſin is rendered tranſparent, and of a fine clear amber yellow, by mixing it when melted with about an eighth of boiling water, and ſtirring it inceſſantly for a conſiderable time till the water is cold. The reſin is then caſt into moulds and cooled.

Eſſential Oil of Turpentine. This valuable oil is prepared largely, both in the countries where the turpentine is extracted, and from turpentine imported into this country. The proceſs is the following: an alembic with a worm and cooler, is uſed, preciſely of the ſame conſtruction as what is employed for the diſtillation of ſpirits; this is filled with turpentine and water in due proportions, and the volatile part after diſtillation is found to conſiſt of oil of turpentine ſwimming on water. This oil is perfectly limpid and colourleſs, has a very ſtrong ſmell, a bitteriſh taſte, is extremely inflammable, and in ſhort poſſeſſes all the properties of the other eſſential oils. It is employed in immenſe quantities in a variety of varniſhes and ſimilar preparations, but for the finer purpoſes ſuch (for example) as that of diſſolving gum copal, it is neceſſary to rectify it by a ſecond diſtillation with water in a ſtill, uſing a very gentle heat, and keeping apart the firſt product which is the beſt. From 250 lbs. of good turpentine about 60 lbs. of oil may be obtained.

Common Roſin. Yellow Roſin. Colophony. The reſidue from the diſtillation of the oil of turpentine, is an opake, brittle, light yellow maſs, much leſs clammy and coheſive than inſpiſſated turpentine, and requiring a greater heat for fuſion: it is the common reſin or roſin of the ſhops. It is alſo called by the French *Brai-ſec,* as well as the boiled *galipot* or harder turpentine, but the latter is more eſteemed as it ſtill contains a good deal of eſſential oil, and is fitter for moſt of the purpoſes for which the terebinthinate ſubſtances are employed. When common roſin is boiled with water for a time, it becomes yellow and tranſparent, and is then the roſin uſed by muſicians to rub the bows and ſtrings of violins. When common roſin is kept in fuſion for a conſiderable time, it becomes of a browner colour, is ſtill harder and leſs adheſive to the fingers when cold, and is then called *Black Roſin* or *Colophony,* and this is the ultimate point to which the inſpiſſation of turpentine is carried.

There are other leſs important varieties in the products of common turpentine, which it is needleſs to deſcribe.

A very fine eſſential oil is prepared in ſome parts of Germany, by diſtillation of the green tops and cones of the Stone Pine (*Pinus Cembra*) which is known in medicine by the name of *Oleum Templinum,* or popularly, *Krumholzoel,* and is an approved remedy for a number of complaints. It is ſomewhat greeniſh, or ſometimes of a golden yellow, very fragrant and aromatic.

The true *Burgundy Pitch* is a brittle opake light-yellow or ſometimes reddiſh-brown reſin, of a fine terebinthinate ſmell and taſte, which is chiefly imported from Saxony, and is collected in quantity in the neighbourhood of Neufchatel from the Norway Spruce Fir.

Inciſions are made in the uſual manner, and the ſurface of the wood laid bare, which is ſoon covered with a turpentine, leſs liquid than the common ſort, and which therefore ſoon concretes on the inciſion without flowing down. This is picked off, and when a ſufficient quantity is collected it is put with water into large boilers, melted, and then ſtrained under a preſs, through cloſe cloths into barrels, in which it is tranſported for ſale. Burgundy pitch is of ſuch a conſiſtence that it will barely ſoften by the heat of the human body, and is much uſed in plaſters. It is often adulterated (as is ſuppoſed) by a mixture of roſin and turpentine.

Burgundy Pitch is alſo obtained from the Larch.

The ſubſtance commonly called *Frankincenſe,* (*Thus*) is a ſolid brittle reſin in ſmall roundiſh maſſes of a browniſh yellow on the outſide, and white internally. It poſſeſſes the common properties of the turpentines, and has a very pleaſant ſmell when burned. It is ſuppoſed to exſude ſpontaneouſly (and not by inciſion) from the Norway Spruce, and to undergo no preparation.

All the terebinthinate ſubſtances above deſcribed are either nearly in the ſtate in which they exſude from the tree, or are prepared by heat with the intervention of a ſuitable apparatus.

There is another product more important than any other, eſpecially to a maritime country, which is prepared by a kind of diſtillation *per deſcenſum,* with no inconſiderable ſkill, but often without any other apparatus than the ſubſtance itſelf that yields it, and this is common *Tar.*

Tar.—Goudron, *Fr.* is a thick dark brown or black reſinous adheſive juice melted by fire from the wood and roots of old pines and fir trees, during which proceſs the wood itſelf is reduced to charcoal.

Every part of the tree which is at all reſinous is fit for obtaining tar, but in particular it is the red wood and the hard roots that yield the greateſt quantity and the beſt. As the wood is entirely charred in the proceſs, all the ſap and other volatile parts muſt be expelled, moſt of which mixes with the turpentine, which ſweats out and conſtitutes tar, and hence this ſubſtance muſt conſiderably vary in the quality and proportion of reſin, empyreumatic oil and acid which it contains, according to the age of the tree, the ſoil on which it grows, the part ſelected, the management of the heat, &c.

The extraction of tar from pine-trees is very antient, being deſcribed by Theophraſtus, Dioſcorides, and other old authors, and the method of proceeding was extremely ſimple. Very large ſtacks were made of billets of pine and covered with turf to prevent the volatile parts from being diſſipated. They were then kindled and ſuffered to burn with a low ſmothered flame, during which the tar melted out by the heat, flowed to the bottom of the ſtack, and ran out by a ſmall channel cut for the purpoſe. A very large proportion of the tar actually made in Norway, and the other Baltic countries, is prepared in this rude manner. The ſtacks are built upon the ſlope of a hill, covered with moſs and turf, kindled, and the tar that oozes out is collected and put into barrels.

But a more economical and ſcientific method is practiſed in France and Switzerland, which is to heat the wood in large brick ovens built for the purpoſe, whereby the wood is charred much more equally, and the tar is of a more uniform, and probably a better quality. The following is the method of proceeding in the Valais: the pines are previouſly felled in the preceding year that the wood may be dry enough when wanted, and the outer bark and twigs being ſtripped off, the reſt of the tree is cut up into billets of tolerably equal ſize. The oven is built of ſtone or brick in the form of an egg ſtanding on its ſmall end. The floor is made either of a ſingle ſtone ſcooped out into a hollow, or of ſeveral joined very accurately. On one ſide of it, about five inches above the loweſt part, is a hole in which a large gun-barrel is thruſt, which ſerves to convey off the liquid tar as it collects. A large iron grate is laid at the bottom of the oven. The largeſt of theſe ovens are about ten feet high, and five or ſix feet in the largeſt diameter. To charge the oven, bundles of theſe billets are thrown in, and the wood ſpread as evenly as poſſible, filling the interſtices with the chips, till it nearly reaches the top. The whole is then covered with a layer of chips, and the top of the furnace is cloſed with flat ſtones heaped one upon the other, gradually leſſening the opening, and forming a kind of vaulted chimney, the mouth of which is four or five inches acroſs. The dry chips at top of the furnace are then ſet on fire, and the heat ſpreads downwards till the whole of the charge is judged to be ſufficiently kindled. The chimney is then entirely cloſed with a large ſtone, and wet earth is heaped on the ſtones at top, and thrown on wherever the ſmoke burſts out too ſtrongly. The melting now begins, the tar falls down to the bottom, fills the hollow of the floor (which laſt detains any bits of wood and other impurities) and runs off through the gun-barrel into caſks placed to receive it. Some ſkill is required in managing the fire, which muſt ſometimes be refreſhed by letting in a ſmall draught of air through ſmall holes left for the purpoſe in the ſides of the kiln. When the proceſs is over, the wood is found compleatly charred, and is taken out, and the oven after being cleared out is again filled. It is found that the red wood and knots, which are the richeſt in reſin, will yield about a fourth of their weight of tar, but the general average of product is about 10 or 12 per cent. of the weight of the whole charge. After each proceſs a quantity of *lamp-black* is collected beneath the ſtones that form the vault of the temporary chimney.

This latter ſubſtance is alſo another product from the pine, and in the large way is procured by a different proceſs, as deſcribed under the article *Carbon*.

A ſubſtance ſomewhat reſembling tar, called *Brai-gras*, and much uſed in the French ports for careening ſhips, is made in the following way. The oven above deſcribed is charged with alternate layers of chips of green wood, and billets of dry, and all the refuſe matter of turpentine, the ſtraw through which it is ſtrained, and the like. Over the whole is laid a ſtratum of *brai-ſec*, or roſin, and the gun-barrel pipe is ſtopped up, and not tapped till the whole of the wood is reduced to charcoal. The vault of the oven is alſo covered more carefully after the charge is ſufficiently kindled, and the whole proceſs is carried on more ſlowly. The heat of the fire melts the roſin at top, which mixes with the reſinous ſap, and the whole collects into a dark reſinous liquid at the bottom. When ſufficiently cooled it is drawn off and barrelled. The *brai-gras* is of an intermediate conſiſtence, between tar and roſin.

Pitch. The ſubſtance called Pitch in this country, is ſimply tar, inſpiſſated to the requiſite degree by boiling.

It does not appear, however, that the French have this preciſe preparation, as the ſubſtance called *Poix* is made either by melting together due proportions of roſin with tar, or elſe by filling a kind of oven with various refuſe matters from the turpentine, ſuch as the ſtraw through which it has ſtrained, together with the coarſe ſtrainings, chips of bark ſoaked in turpentine, the broken earth of the moulds in which the reſin collects, &c. kindling it till all the reſin falls down into a reſervoir, and continuing the heat till it is ſufficiently inſpiſſated. This forms a hard black maſs called *Poix dure* or *Pegle.*

The pitch made in this country by boiling down tar to the proper conſiſtence, is now performed near London, and in ſome other parts, in a ſtill with a worm-tub attached to it, in order to collect the valuable volatile products of the tar. The proceſs is the following:[b] the barrels of tar being of various conſiſtence, their contents are firſt emptied into a copper, and gently heated and well ſtirred, to render them thin and uniform. The tar is then laded into the ſtill, paſſing through a ſieve to keep out chips of wood and other impurities.

When the ſtill is properly luted, the fire is kindled and kept up very moderate for three hours, as the tar is very apt to boil up in the early part of the proceſs. The firſt product that diſtills over is principally a brown acid water, mixed however with a good deal of oil. As the proceſs advances, and the heat is increaſed, the quantity of acid leſſens, and that of oil increaſes, and towards the end of the diſtillation the product is chiefly oil. The length of the proceſs varies according to the quality and hardneſs of the pitch required. In general a ſtill that holds about 600 gallons will work 18 or 20 barrels of tar in 8 hours, the produce of which will be about 10 barrels of pitch (or 22 cwt.), 176 gallons of oil; and about 40 gallons of acid. The pitch remains in the ſtill for 12 hours, after which it is barrelled, and hardens as it cools.

The oil and acid water which diſtill over do not mix, ſo that they may be eaſily ſeparated by decantation. The oil is a browniſh inferior kind of oil of turpentine, which is very uſeful in painting ſhips and other coarſe out-door work. The acid is a very ſtrong browniſh empyreumatic acid, which appears very cloſely to reſemble the pyroligneous acid obtained from the diſtillation of wood during its converſion to charcoal, and is now employed pretty largely in compoſing ſeveral of the mordants in callico printing.

TURPENTINE (*Chio.*)

This is a very fragrant reſin, obtained ſparingly by inciſion of the bark of the *Piſtacia Terebinthus*, a ſmall tree growing in the Iſle of Chio, and in many other parts of the Levant.

It is a thick and tenacious ſubſtance, whitiſh, nearly tranſparent, highly fragrant, and almoſt taſteleſs. It is ſeldom found genuine, the common Chio turpentine of the ſhops being largely adulterated with the finer ſorts of the pine turpentines.

TURQUOISE.

The colour of this ſubſtance is pale ſky-blue, paſſing into indigo-blue and pale apple green. It occurs in maſs or diſſeminated. Its fracture is even. Its hardneſs is nearly equal to that of glaſs; it is difficultly frangible. Sp. gr. 3.12.

Before the blowpipe its colour changes to greyiſh white, and it becomes friable, but does not melt. It is ſoluble in nitro-muriatic acid, and the European varieties are ſo in nitric acid; this menſtruum however has no action on the Perſian turquoiſes. It is compoſed, according to Buillon La Grange, of

80	Phoſphat of lime
8	Carbonat of lime
2	Phoſphat of iron, with a trace of mangineſe
2	Phoſphat of magneſia
1	Alumine
6	Water and loſs
99	

Turquoiſe is generally conſidered as foſſil bone, or ivory penetrated by oxyd of copper; it appears, however, from the above analyſis, that the colouring matter is phoſphat of iron. The oriental turquoiſes are found near Meched in Perſia, alſo in Mount Caucaſus, in Egypt and Arabia. The occidental ones are found in Languedoc in France, and in Hungary. Turquoiſe was formerly in ſome eſtimation for rings and other articles of perſonal ornament, but its value has greatly declined in modern times. The colour of turquoiſe changes gradually by expoſure to the air, from blue to green: when it arrives at this ſtate its commercial value is wholly extinct.

TUTENAG. See COPPER, alloys of.

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[b] Original Communication.

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ULTRAMARINE. *Outremère.* Fr.

This precious colour ſo remarkable for its beauty and durability is a pure deep ſky blue. It is capable of bearing a low red heat without injury, and it is not ſenſibly impaired by the action of the air and weather. It is the colouring matter of the mineral already deſcribed under the name Lapis Lazuli, and appears according to an analyſis by Klaproth, to conſiſt of little elſe than oxyd of iron. The method in which this pigment is ſeparated from the earthy parts of the above mineral is as follows. Let the lapis lazuli be heated juſt to redneſs, and then ſuddenly quenched in cold water, and let this be repeated two or three times till the ſtone becomes almoſt friable; then let it be ground down with a few drops of water in a clean iron mortar, or ſtill better, in an agate one till it is reduced to a perfectly impalpable powder. Then take one pint of linſeed oil, warm it over the fire in a clean veſſel, and add one pound of bees-wax, one pound of turpentine, half a pound of roſin, and half a pound of gum maſtich: keep the ingredients over the fire, with conſtant ſtirring till they are melted and thoroughly incorporated together; the reſult will be a tenacious adheſive maſs. Of this take any quantity, 6 oz. for example, melt it and pour it into a warm clean mortar; then ſprinkle upon it 3 oz. of pulverized lapis lazuli, and incorporate it thoroughly by long beating with the peſtle; this being done pour in ſome warm water, and again work it about in the ſame manner as before: in a ſhort time the water will become charged with the blue colouring matter; it muſt then be poured into a clean tall glaſs, and replaced by freſh, proceeding in this manner till the paſte will give out no more colour on the addition of freſh water. By ſtanding a few days the colour will ſubſide from the water in which it was ſuſpended; the clear fluid being then decanted off, and the reſt got rid of by evaporation, there will remain a deep-blue powder which is ultramarine.

UMBER.

There are two kinds of umber, the one called *Cologne Umber*, is a variety of peat or of earthy brown coal. There are large beds of it wrought in the neighbourhood of Cologne, principally as an article of fuel; a pretty conſiderable quantity is alſo imported into Holland, where it is uſed in the manufacture, or more properly in the adulteration of ſnuff, for which purpoſe it appears to be better than the common peat of the country; a ſtill ſmaller quantity is conſumed by the paint-makers.

The colour of this vegetable umber is a warm ſomewhat pinkiſh brown, and is an uſeful ingredient to the painter in water colours.

The ſecond kind of umber goes by the name of *Turkiſh umber*, and appears to be a variety of the iron ore called brown ironſtone ochre. A ſpecimen from Cyprus was analyſed by Klaproth,[a] and afforded him,

48	Oxyd of iron
20	Oxyd of manganeſe
13	Silex
5	Alumine
14	Water
100	

URANIUM.

Uranium is a brittle hard metal, of extremely difficult fuſibility. It is ſoluble in nitro-muriatic acid, and is precipitable from its ſolution of a yellow colour by cauſtic alkali, and of a browniſh-red by pruſſiated potaſh.

§ 1. *Ores.*

Sp. 1. Black Uranium. *Pecherz*, Wern. *Pechblende*, Widenm, &c.

Its colour is velvet black paſſing into iron-grey and browniſh black; it is ſometimes ſuperficially tarniſhed like tempered ſteel. It occurs in maſs, diſſeminated, and in ſmall reniform pieces. Internally it has uſually a gliſtening ſemi-metallic luſtre; its fracture is imperfectly conchoidal, paſſing into granular uneven. It ſometimes occurs in thick lamellar or granular diſtinct concretions. It is moderately hard, paſſing to ſoft, is brittle and eaſily frangible. Sp. gr. = 7.5.

It is infuſible *per ſe* before the blowpipe; with ſoda or borax it forms a dull greyiſh ſlag, and with the alkaline phoſphats a clear green glaſs. It is ſoluble in nitric acid, giving out abundance of nitrous gas.

A ſpecimen from Bohemia was analyſed by Klaproth, (to whom the diſcovery of the new metal which it contains is owing) with the following reſult.

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[a] Analyt. Eſſ. vol. ii. p. 106.

86.5	Uranium in the ſtate of ſub-oxyd
2.5	Black oxyd of iron
6.	Sulphuret of lead
5.	Silex
100.0	

Of theſe ingredients the two laſt appear to be only caſual, for in an analyſis by Lampadius, of a ſpecimen of this mineral from Saxony, there were obtained only uranium and iron; in another there was a ſlight admixture of copper pyrites.

It occurs in veins in primitive mountains, mixed with ores of lead and ſilver, with copper pyrites, iron ochre, and cobalt. It is found at Joachimſthal in Bohemia; Johanngeorgenſtadt, in Saxony; and Kongſberg in Norway.

It is diſtinguiſhable from blende, with which it was formerly confounded, by its ſpecific gravity, and fracture, as well as chemical characters.

Sp. 2. Micaceous Uranium. *Uran-glimmer*, Wern. *Urane micacé*, Broch.

Its uſual colour is graſs green of more or leſs intenſity, whence it paſſes on one hand to greeniſh ſilvery white, and on the other to ſulphur yellow. It occurs ſometimes as a ſuperficial cruſt but more uſually cryſtallized in the form of rectangular tables; theſe tables are ſometimes ſo thick in proportion to their other dimenſions as to approach to the cube, and ſometimes two oppoſite terminal planes are ſo deeply bevilled on all their edges as to give the entire cryſtal the appearance of a truncated octohedron; the cryſtals are generally very ſmall, and cellularly aggregated; the terminal planes are ſtriated, the lateral ones are ſmooth; the external luſtre is more or leſs ſhining; the internal is gliſtening and pearly; the fracture is ſtrait foliated in a ſingle direction. It is tranſlucent, ſoft, not brittle, but eaſily frangible. Sp. gr. 3.12.

It is ſoluble in nitric acid without efferveſcence, and communicates to it a yellow colour. The yellow variety of this mineral appears from an aſſay by Klaproth, to be pure oxyd of uranium; the green varieties contain a little oxyd of copper, to which that colour is owing.

It occurs in veins of ironſtone in primitive mountains, accompanied by the other ores of this metal, and ſometimes by cobalt, and arſeniat of copper. It is found at Carrarach in Cornwall, Eibenſtock in Saxony, Saſka in the Bannat, and St. Symphorien near Autun in France.

Sp. 3. Ochery Uranium. *Uranokker*, Wern. *Ocre d'Urane.* Broch.

Its colour is ſtraw-yellow paſſing into orange and greeniſh yellow. It occurs ſuperficial, diſſeminated, and maſſive; it is dull or ſlightly glimmering; its fracture is earthy paſſing into ſmall and imperfectly conchoidal. It is opake, ſoft, ſometimes even friable; is brittle and meagre to the touch. Sp. gr. = 3.2.

The yellow varieties, according to Klaproth, are pure oxyd of uranium, the orange coloured contain a ſmall admixture of iron.

It occurs with the other ores of uranium.

§. 2. *Aſſay and Analyſis.*

The analyſis of the ores of uranium is ſufficiently ſimple. The only ſubſtances that have hitherto been found in natural mixture or combination with this metal, are lead, iron, copper, ſulphur, and ſilex, which may all be ſeparated in the following manner.[b]

a. Let the ore be digeſted with moderately dilute nitric acid, by which the greater part of it will be taken up; the reſidue being waſhed and dried is to be gently ignited, by which the *ſulphur* will be burnt off; what remains after ignition is to be digeſted with dilute nitric acid, and the inſoluble portion is *ſilex*.

b. To the nitric ſolutions and waſhings mixed together, is to be added ſulphat of ſoda as long as any precipitate falls down; this when collected on a filter, waſhed and dried, is ſulphat of *lead*.

c. The remaining ſolution is to be totally decompoſed by cauſtic fixed alkali, at a boiling heat, and the powder thus obtained is to be digeſted in cauſtic liquid ammonia till the whole of the copper is taken up. The ammoniacal ſolution being then ſlightly ſuperſaturated by ſulphuric acid, the *copper* may be obtained either in the metallic ſtate by means of a bar of iron or zinc, or in the ſtate of brown oxyd, by boiling with cauſtic fixed alkali.

d. The reſidue of the precipitate *c.* after extraction of the copper, is to be evaporated to dryneſs two or three times with nitric acid, and is then to be gently digeſted in dilute nitric acid, which will take up the uranium, leaving the iron behind in the ſtate of per-oxyd.

e. The nitrat of uranium being boiled with cauſtic fixed alkali the whole of the uranium is precipitated as pure yellow oxyd.

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[a] Klapr. Analyt. Eſſ. vol. i. p. 476.

§ 3. *Chemical and Phyſical Properties.*

The method of obtaining reguline uranium, according to Klaproth, though ſimple, is not very eaſy, on account of the high heat required for this purpoſe; it being greater than that neceſſary for the reduction of oxyd of manganeſe; 50 grs. of the pure yellow oxyd being made up into a ball with wax were placed in a cloſe crucible lined with charcoal, and expoſed for ſome hours to the moſt intenſe heat of the Berlin porcelain furnace, equal to 170° Wedg. There was thus obtained a metallic button weighing 28 grs. of an iron-grey colour and metallic luſtre, compoſed of hard minute grains, firmly adhering to each other. Its ſp. gr. was = 8.1. Other attempts to reduce the yellow oxyd by the aſſiſtance of borax and other ſaline fluxes entirely failed; the reſult being only a black vitreous ſcoria.

Uranium is ſoluble with efferveſcence in nitric acid, nitrous gas being at the ſame time given out, but the other ſimple acids appear to have little or no action on it, neither does it appear to be affected by the alkalies. It is not eaſily oxydized by expoſure to air and heat, at leaſt no change is produced in it by the blowpipe on charcoal.

Uranium appears capable of two ſtates of oxydation; the method of procuring the yellow or per-oxyd, we have already mentioned in the preceding ſection. The black or ſub-oxyd may be procured by mixing the yellow oxyd with oil, and then gently burning it off on a teſt; from 120 grs. of yellow oxyd treated thus, Klaproth procured 85 grs. of black oxyd. This latter differs from the former, not only in colour, but in its producing nitrous gas when digeſted with nitric acid. The relative compoſition of the two oxyds, as deduced from the above facts, is,

56 metal + 44 oxygen = 100 of yellow oxyd,
79.9 metal + 20.1 oxygen = 100 of black oxyd.

The yellow oxyd is readily ſoluble in acids. When digeſted with diluted ſulphuric acid it readily diſſolves, and by evaporation and cooling depoſits ſulphat of uranium in the form of ſmall priſms of a lemon yellow colour. Dilute nitric acid diſſolves the oxyd of uranium with facility, and the ſalt hence reſulting cryſtallizes in oblong hexagonal tables of a light green colour. Muriatic acid in like manner takes up this oxyd and cryſtallizes in the form of rhomboidal tables, of a greeniſh yellow colour. Concentrated diſtilled vinegar takes up the oxyd of uranium by digeſtion, and forms clear topaz-yellow cryſtals in the form of tetrahedral priſms terminated by tetrahedral pyramids; when theſe cryſtals are very ſlowly ignited, the acid is driven off, and nothing but the oxyd remains, without the form of the cryſtals being injured. Phoſphoric acid is capable alſo of diſſolving this oxyd but the ſolution in a ſhort time becomes turbid from the precipitation of a flocculent ſub-phoſphat of a yellowiſh white colour.

All the above ſolutions are decompoſable by cauſtic alkali, a lemon yellow oxyd being thrown down. Carbonated alkali throws down a yellowiſh white precipitate which is partly reſoluble in an exceſs of mild alkali. Pruſſiat of potaſh throws down from theſe ſolutions a copious browniſh red precipitate reſembling kermes mineral. Hydroſulphuret of ammonia occaſions a browniſh yellow precipitate; and tincture or infuſion of galls a copious chocolate brown one.

The affinity of this oxyd for the acids is ſo conſiderable that its ſalts are not decompoſed by the addition of zinc or of any other metal.

The following vitreſcent mixtures were made by Klaproth, to aſcertain the power of this oxyd as a colouring ſubſtance.

Silex — — —	2 drachms
Carb. potaſh — —	1 drachm
Yellow oxyd — —	10 grs.

produced a clear light brown glaſs.

Silex — — —	2 drachms
Carb. ſoda — —	1 drachm
Yellow oxyd — —	10 grs.

produced an opake blackiſh grey glaſs.

Silex — — —	2 drachms
Glaſs of borax — —	2 drachms
Yellow oxyd — —	20 grs.

produced a clear glaſs of a ſmoke-brown colour.

Silex — — —	2 drachms
Vitreous phoſphoric acid (from bones) —	2 drachms
Yellow oxyd — —	20 grs.

produced an opake apple-green glaſs, like chryſopraſe

Vitreous phoſphoric acid	2 drachms
Yellow oxyd — —	10 grs.

produced a clear emerald-green glaſs.

The glaſs produced by the two latter experiments was however in ſome degree deliqueſcent.

The yellow oxyd when mixed with the common enamelling flux, tinges porcelain of a deep orange yellow.

The alloys of uranium are as yet wholly unknown.

UREA. See Urine.

URIC, or LITHIC ACID. See Urinary Calculus.

URINARY CALCULUS.

In the bladder of many animals, and particularly of man, hard round concretions, ſtony in appearance, are frequently formed, which produce moſt dreadful paroxyſms of pain and general diſeaſe, for which no radical cure has hitherto been diſcovered, except a very ſerious ſurgical operation.

The ſtone of the bladder has been examined with extreme attention by ſeveral moſt excellent chemiſts, who have been ſtimulated by the additional hope of finding a ſolvent which might remove it altogether, or at leaſt mitigate the ſeverity of the ſymptoms which it produces, and it was early diſcovered that a conſiderable benefit was derived from the internal uſe of alkaline medicines, taken in as large quantity as could be borne, and for a length of time.

The firſt and by far the moſt important diſcovery relating to the chemical nature of calculus, was made by Scheele, in 1776,[a] who obtained from it a large proportion of a peculiar cryſtallizable ſubſtance till then unknown, which had all the properties of a very weak acid, particularly in reddening litmus, and neutralizing alkaline and earthy baſes. This ſubſtance was afterwards denominated the *Lithic Acid*, and more lately the Uric Acid. This diſcovery gave a new intereſt to the examination of calculi, and many additional obſervations have been added by other chemiſts. Bergman, who was employed on the ſame ſubject at the ſame time with Scheele, gave ſome further remarks on its habitude with acids. Dr. Wollaſton[b] has ſhewn that the gouty calculus, or *chalk ſtone*, as it is generally called, conſiſts of the lithic acid neutralized by ſoda, and has alſo added largely to our knowledge of the varieties of urinary calculi, by diſcovering that phoſphat of ammonia and magneſia is the compoſition of one ſpecies; that pure phoſphat of lime forms another ſpecies; and that the variety known to ſurgeons by the name of the mulberry calculus, conſiſts of phoſphat and oxalat of lime.[c] Dr. Pearſon in analyſing 200 ſpecimens of calculi, has found the lithic acid of Scheele in all but ſix, in very various proportions, but he conſiders this peculiar ſubſtance rather as an animal oxyd than an acid. Brugnatelli and other chemiſts whom it is needleſs to enumerate, have thrown ſome further light on this ſubject; and laſtly, a long and moſt elaborate ſeries of experiments has been made by Meſſrs. Fourcroy and Vauquelin, which gives the fulleſt and moſt comprehenſive view of the ſubject.[d]

From all theſe authorities we may collect the following particulars:

The greater number of urinary calculi or ſtones of the bladder, are of a round or oval ſhape, varying in ſize from that of a bean to the bigneſs of a pullet's egg; brittle, hard enough to take a good poliſh; when ſawn through obviouſly compoſed of concentric laminæ formed round a ſmall nucleus; of a dull yellow to a red gravelly colour, often interſperſed with blood-red ſpots; and the ſpecific gravity of even the heavieſt, does not quite amount to 2. Theſe are the calculi in which the lithic or uric acid enters as a conſtituent part, but even in theſe there is a conſiderable variety of texture and appearance, the ſurface being ſometimes ſmooth and poliſhed, ſometimes rough, with ſmall protuberances, and occaſionally interſperſed with cryſtals, which latter are the ammoniaco-magneſian phoſphat.

The *mulberry calculi*, as they are called, are diſtinguiſhed by their mamillated, and uſually poliſhed ſurface, reſembling that of the mulberry, and their colour too is generally much darker. Theſe, as before mentioned, have been found by Dr. Wollaſton to conſiſt chiefly of oxalat of lime. The analyſis of this and of the other rarer varieties, will be mentioned after we have deſcribed the common lithic calculus, which is particularly diſtinguiſhed by its lamellar texture, its toughneſs, and the uniform brown yellow colour of the inner part, a good deal reſembling petrified wood in appearance.

When this calculus is boiled for ſome time in water, a ſolution is obtained holding about 8 grains in 5 oz. of liquid, which reddens litmus paper.[e] As it grows cold the greateſt part of the diſſolved portion of calculus ſeparates again in the form of fine cryſtals, which are the pure *Lithic* or *Uric* acid. The muriatic acid has no effect on this calculus. Concentrated ſulphuric acid diſſolves it by the aſſiſtance of heat. But the moſt characteriſtic effects are thoſe produced by the nitric acid. When this acid, ſomewhat dilute, is boiled on the calculus, the latter is entirely diſſolved, red vapours ariſe, and a good deal of carbonic acid gas is produced.

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[a] Eſſays.

[b] Phil. Tranſ. for 1797.

[c] Ibid. for 1798.

[d] Syſtemé de Conn. Chem. tom. 10.

[e] Scheele.

The ſolution is acid, though more of the calculus is added than the nitric acid can diſſolve; it is of an orange-yellow colour, which reddens by evaporation, and produces roſe-coloured ſpots on the ſkin about half an hour after it has been applied. This ſolution is not precipitated by any cauſtic alkali, but when an exceſs of it is added, an alkaline ſolution is produced, which is of a roſe-colour when heated, and tinges the ſkin equally with the acid ſolution.

Lime water decompoſes the ſolution, and gives a white precipitate, which however is not uric acid or urat of lime, but oxalat of lime, owing to the production of ſome oxalic acid by the action of the nitric acid. This is confirmed by the more compleat action of the oxymuriatic acid,[f] for when a lithic calculus is digeſted on this liquid, or, ſtill more readily, when this acid gas is paſſed through water, holding the calculus ſuſpended in fine powder, the colour of the latter grows paler, it ſwells, ſoftens, becomes gelatinous in appearance, and diſſolves almoſt entirely with the gentle evolution of bubbles of carbonic acid gas. The uric acid is now entirely loſt, and the ſolution contains muriatic acid, ammonia, and the oxalic and malic acids. Of theſe, the two latter ſubſtances are entirely generated from the uric acid, by means of the oxymuriatic, and the ammonia is either totally produced by the ſame means, or partially, when the calculus previouſly contained a ſmall portion of this alkali, which is ſometimes the caſe. But there can be no doubt that part of the volatile alkali that appears, is actually produced in this inſtance, ſince the pure uric acid will yield it by fire in caſes when none of it appears in treatment with the fixed alkalies.

When this calculus is boiled with the carbonated alkalies, little if any effect is produced, but the cauſtic fixed alkalies diſſolve it readily, even in the cold, when there is an exceſs of the alkali. This ſolution is yellow, taſtes ſweetiſh, and alkaline, but when neutralized, the alkaline urat cryſtallizes. Liquid ammonia alſo diſſolves the calculus, though with difficulty. Lime-water has the ſame effect, and the cauſtic taſte of the lime diſappears. In all theſe caſes a true neutral ſalt is produced of the uric acid and the alkali or alkaline earth employed, which is ſoluble in water. Theſe ſolutions are decompoſed by every acid, even the carbonic, ſo that the uric acid has an extremely weak affinity with the ſeveral baſes. Theſe decompoſitions too are much aſſiſted by the extremely ſparing ſolubility of the uric acid alone, ſo that as ſoon as any other acid is added to the urat, the uric acid is depoſited in ſmall, brilliant, bulky, needled cryſtals, of a faint yellow or wood colour. This is the moſt convenient method of procuring this acid for examination, namely, by digeſting the uric calculi in hot cauſtic potaſh or ſoda, and then ſeparating it by muriatic acid. Carbonat of ammonia will alſo ſeparate the uric acid from its alkaline ſolutions, owing no doubt to the ſimple agency of the carbonic acid which this ſalt contains in ſuch abundance, its ammonia being volatilized in the proceſs.

When a portion of this calculus is heated *per ſe* in a retort, an ammoniacal watery liquor riſes, but no oil. This is accompanied by a brown ſublimate, which may be whitened by a ſecond ſublimation, and is then without ſmell, has a ſouriſh taſte, is eaſily ſoluble in boiling water, and is ſomewhat different from the uric acid formed by precipitation of the alkaline ſolution. A good deal of carbonic acid is given out during the heating of the calculus, and a ſtrong fetid ſmell like burnt horn is perceived, together with an odour like peach-flowers, which indicates Pruſſic acid.

The uric acid is contained in ſmall quantity in the moſt healthy urine,[g] for if ſome of this liquid is evaporated it depoſits a fine red powder, which is ſoluble in alkali, and has all the properties of urinary calculus. The red ſediment which ſettles from the urine of perſons after an ague fit, is of the ſame nature.

The uric acid therefore, though it has many properties ſimilar to the benzoic, and others reſembling the ſuccinic, muſt at preſent be conſidered as a diſtinct acid, which occurs only in urine and in moſt kinds of urinary calculi, and is diſtinguiſhed by its ſparing ſolubility in water, by its ſeparation in a cryſtalline form from its alkaline ſolution by every acid, by its ſolubility in nitric acid, and the roſe-coloured tinge with which it ſtains the ſkin, by the acid ſublimate and the ammonia which it gives when ſublimed, and the very ſmall quantity of animal oil which is produced under the action of fire.

Urat of ammonia is often found in urinary calculi. The preſence of ammonia as an *educt* and not a *product*, is aſcertained by the pungent ammoniacal ſmell which is given out when this calculus is digeſted with a fixed alkali. The calculi, of which it forms the principal part,[h] are generally ſmall, coffee-coloured, arranged in thin roughiſh laminæ, uſually with a depoſition of phoſphat of lime interpoſed, and often intermixed with ammoniaco-magneſian phoſphat.

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[f] Fourcroy.

[g] Scheele.

[h] Fourcroy.

Urat of ſoda has been found by Dr. Wollaſton to be the compoſing ingredient of the gouty chalk-ſtones, or calculi depoſited under the ſkin, chiefly in the neighbourhood of the joints, and which may be mentioned in this place. If a ſmall quantity of dilute ſulphuric acid is poured on the chalk-ſtone, part of the alkali is extracted, and cryſtals of Glauber's ſalt may be obtained from the ſolution. Muriatic acid, in like manner, produces common ſalt. The inſoluble reſidue is the uric acid. Boiling water diſſolves rather more of the chalk-ſtone than it would do of pure uric acid, and an urat of ſoda cryſtallizes by cooling. If lithic acid be triturated with ſoda and water, they unite, and a compound is formed, which, when the ſuperfluous alkali has been waſhed out, very cloſely reſembles the chalk-ſtone.

Phoſphat of Ammonia with Magneſia.

A ſpecies of urinary calculus exiſts, which was firſt noticed by Mr. Tennant to differ from common calculi in being fuſible under the blowpipe into an opake white glaſs, inſtead of being almoſt totally conſumed; whence this able chemiſt conjectured it to be phoſphat of lime, united with ſome other phoſphoric ſalt. This conjecture was found to be almoſt exact, by the ſubſequent analyſis of Dr. Wollaſton, who aſcertained its compoſition to be a triple ſalt, compoſed of phoſphoric acid, ammonia, and magneſia.

This fuſible calculus is always whiter and harder than the common calculi, and generally has the appearance of ſparkling cryſtals, which are ſometimes voided in the form of a white ſand. The white amorphous calculus of this ſpecies contains, beſides the triple ammoniaco-magneſian phoſphat, ſome phoſphat of lime and a little uric acid, but the cryſtals are the pure triple ſalt. Theſe were analyſed by Dr. Wollaſton in the following manner: the ammonia was firſt driven off by heat, and the cryſtals were rendered opake. Nitric acid then diſſolved the remainder, and by adding nitrat of mercury an inſoluble phoſphat of mercury was formed, whence the mercury was expelled by heat, and the phoſphoric acid remained ſingle. Sulphuric acid added to the ſupernatant liquor produced Epſom ſalt, ſhewing the preſence of magneſia. Theſe cryſtals require a large quantity of water for ſolution, but diſſolve with eaſe in the acids.

This triple ſalt may be readily produced by adding ammonia to phoſphat of magneſia, and the form of the artificial as well as of the native ſalt, is uſually a ſhort three-ſided priſm, terminated by a pyramid of three or ſix ſides.

Fourcroy gives the following diſtinctive characters of this ſalt: it diſſolves readily in the acids, more ſo even than phoſphat of lime: dilute ſulphuric acid in particular forms a clear ſolution. Ammonia only ſeparates ſome ſmall flocculi from this ſolution, whereas it totally precipitates phoſphat of lime. The cauſtic alkalies ſeparate ammonia from this calculus in ſenſible fumes; they do not diſſolve it, but take up the phoſphoric acid and leave the magneſia pure. By all theſe chemical properties this calculus may be readily diſtinguiſhed in analyſis.

Phoſphat of Lime Calculus.

The ſurface of this calculus is generally of a pale brown,[i] and ſo ſmooth as to appear poliſhed. When ſawn through it is found very regularly laminated, and the laminæ in general adhere ſo ſlightly to each other as to ſeparate with eaſe into concentric cruſts. Sometimes the laminæ are ſtriated in a direction perpendicular to the ſurface, giving a cryſtallized fibrous texture. This calculus diſſolves totally and ſlowly in nitric or muriatic acid, and the muriatic ſolution cryſtallizes on evaporation. The phoſphat of lime is precipitated by ammonia Before the blowpipe this calculus at firſt becomes ſlightly charred, owing to the burning of ſome gelatin or other uniting animal matter with which it is intermixed, but it ſoon becomes perfectly white, and at laſt fuſes into an opake globule. This fuſibility depends on the conſiderable proportion of phoſphoric acid which it contains, and in this it differs from the common earth of bones, which holds an exceſs of lime, and is therefore infuſible *per ſe*.

Calculus, with Oxalat of Lime. Mulberry Calculus.[k]

This calculus is the hardeſt and heavieſt of all theſe ſubſtances. Its colour is generally of a dark chocolate-brown externally, and irregularly grey within. Its ſurface is covered with tubercles or rounded knobs like the mulberry: when ſawn through it gives the ſame ſmell as bone or ivory. It is ſoluble with difficulty in acids: the cauſtic alkalies have no action upon it, but when a carbonated alkali is boiled with it for a few minutes, it is completely decompoſed, carbonat of lime is depoſited, and the liquor contains the oxalat of the alkali uſed, mixed with a little phoſphat. If acetited lead is added, a compound precipitate of oxalat and phoſphat of lead is formed, to which if ſulphuric acid is added, ſulphat of lead is produced, and the oxalic acid remains in the ſupernatant liquid, and may be procured in its proper cryſtallized form. This calculus, when calcined in the open air, blackens, and gives an ammoniacal ſmell and the other products of ſoft animal matter, and a white powder finally remains, which conſiſts of quick-lime and phoſphat of lime. The quick-lime is that portion of this earth which was united to the oxalic acid, and its production or complete calcination is a perfectly diſtinguiſhing mark of this ſalt, as no other calcareous ſalt has yet been diſcovered in calculus but the phoſphat, and the acid of this latter is not deſtructible by fire.

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[i] Wollaſton.

[k] Wollaſton, Fourcroy.

The very extenſive and accurate reſearches of Meſſrs. Fourcroy and Vauquelin, on urinary calculi, have diſcovered to them the twelve following diſtinct ſpecies, with the enumeration of which we ſhall conclude this article, referring the reader to the original for a more complete deſcription.[l]

Sp. 1. *Calculi of Uric Acid alone.*

Theſe, which the moſt frequently occur, are diſtinguiſhable by their reſemblance to wood in colour, by having a denſe radiated texture, and by being entirely ſoluble in cauſtic alkali, without giving any ſmell. Their analyſis has been already mentioned. Sp. gr. = 1.27 to 1.78.

Sp. 2. *Urat of Ammonia.*

Theſe are pale-brown, diſpoſed in fine brittle laminæ, with a nucleus in the middle; ſoluble in cauſtic alkali, with diſengagement of ammonia. Muriatic acid takes away the ammonia and leaves the uric acid pure. Sp. gr. = 1.225 to 1.720.

Sp. 3. *Oxalat of Lime. Mulberry Calculi.*

The colour of theſe calculi is brown; the ſurface mamillated, ſometimes approaching to prickly: they are hard, denſe, and take a fine poliſh; and when ſawn give out the ſmell of raſped bone. They are inſoluble in cauſtic alkalies, ſoluble in acids, and when calcined leave pure lime. They alſo abound with an animal matter, like gelatin. Sp. gr. = 1.428 to 1.976.

Sp. 4. *Uric Acid and Earthy Phoſphats, in two diſtinct layers.*

Their colour is white like chalk, they are friable, and contain a nucleus of uric acid, and the phoſphats externally. They can only be diſtinguiſhed when ſawn through. Sp. gr. very variable.

Sp. 5. *Uric Acid and Earthy Phoſphats intermixed.*

The external characters of theſe calculi are extremely variable. Sometimes they appear homogeneous, at other times they are marbled or veined like the onyx. The colour is grey, never of a chalk white, and they are often ſoapy to the touch. Sp. gr. 1.213 to 1.739.

Sp. 6. *Urat of Ammonia and Earthy Phoſphats, in diſtinct layers.*

Theſe reſemble Sp. 4. in appearance, and can only be diſtinguiſhed by analyſis. Generally the nucleus is the urat, and the phoſphats are external; but ſometimes it is the reverſe. Sp. gr. 1.312 to 1.761.

Sp. 7. *Urat of Ammonia and Earthy Phoſphats intermixed.*

Theſe are ſcarcely diſtinguiſhable but by analyſis. Their texture appears at firſt very uniform, but attentive examination will ſhew their diſtinct laminæ of the component ſalts.

Sp. 8. *Phoſphat of Lime and Ammoniaco-Magneſian Phoſphat.*

This ſpecies is of a pure chalk-white, friable, inſoluble in alkalies, diſſolves in weak acids: ſometimes it is of an enormous ſize. Sp. gr. only from 1.138 to 1.471.

Sp. 9. *The nucleus Oxalat of Lime, and covered with a thick coating of Uric Acid.*

This variety can only be diſtinguiſhed by the eye when ſawn through, when each ſubſtance may be recogniſed by its peculiar marks. Sp. gr. = 1.341 to 1.754.

Sp. 10. *A nucleus of Oxalat of Lime, and inveſted with earthy Phoſphats.*

This too requires to be ſawn through to be diſtinguiſhed. It is not uncommon. Sp. gr. = 1.168 to 1.752.

Sp. 11. *Uric Acid or Urat of Ammonia, earthy Phoſphats, and Oxalat of Lime.*

Sp. 12. *Uric Acid, Urat of Ammonia, earthy Phoſphats, and Silex.*

This is made a diſtinct ſpecies on account of the ſilex, which however is very rare.

The above claſſification appears to us ſomewhat too complicated, and many other varieties might doubtleſs be found which would have as good a claim to be conſidered as diſtinct ſpecies as ſome of thoſe here enumerated. It will ſerve however to ſhew the very various nature of urinary calculi, and the total abſence of any one common chemical property; and hence may be demonſtrated the impoſſibility of finding a ſingle ſolvent which would apply to every caſe of this formidable diſeaſe.

URINE. Harn. *Germ.*

Human urine is an extremely compound fluid, but one with the nature of which we are now very accurately acquainted on account of the many excellent and accurate analyſes partial or compleat which it has undergone from ſeveral excellent chemiſts, among whom we may particularly mention Mr. Cruikſhank[m], and a moſt elaborate and maſterly analyſis by Meſſrs.

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[l] Fourcroy's Syſtême, &c. tom. 10.

[m] See Rollo on Diabetes.

Fourcroy and Vauquelin.[b] Its compoſition has been partially explained under the article *Phoſphorus* and *Phoſphats*, as it was the ſubſtance from which phoſphorus was firſt extracted.

The ſubſtances which unqueſtionably compoſe healthy urine before any change has been induced by putrefaction or artificial heat, are the following, viz. water, phoſphoric acid, muriatic acid, uric acid, benzoic acid, carbonic acid, ſoda, potaſh, ammonia, lime, magneſia, gelatin, and a very ſingular ſubſtance peculiar to this fluid, to which was formerly given the vague term of a ſaponaceous extract, but which has more properly been called urea (urée) by the French chemiſts above mentioned. Beſides theſe component parts, Prouſt and ſome other chemiſts have admitted a peculiar reſin, to which the colour and odour is attributed; ſulphur, and ſulphuric acid, united partly with the ſoda and partly with the lime. But theſe three laſt ſubſtances are doubtful, and they may be paſſed over.

Of the above mentioned indubitable ingredients of urine all the acids are nearly, but not entirely, ſaturated with one or other of the reſpective baſes (for a ſlight exceſs of acid is ſhewn in recent urine by its reddening litmus) ſo that a number of neutral ſalts are formed, and may be actually extracted by ſimple proceſſes. Of theſe the moſt important are, muriat of ſoda and potaſh; phoſphat of lime; phoſphat of ſoda; and phoſphat of ſoda with ammonia, a ſalt long celebrated under the term *Microcoſmic ſalt*, or *Fuſible ſalt of Urine*. Beſides theſe, after putrefaction has begun in this fluid, a conſiderable quantity of ammonia is generated, which not only ſaturates the exceſs of acid, but gives a very ſenſible alcaleſcency, and cauſes the production of ſome other neutral ſalts, particularly the urat of ammonia; benzoat of ammonia; and, by uniting with the phoſphat of magneſia it forms the triple ammoniaco-magneſian phoſphat deſcribed in the article of urinary calculus.

Urine, recently made by a perſon in health, is a clear yellow fluid, varying in ſpecific gravity from 1.033 to 1.005,[c] according as it is more or leſs watery, of a peculiar ſmell, a very acrid ſaline taſte, and ſlightly acidulous ſo as to redden litmus. After ſtanding for ſome hours it becomes turbid, and a red matter is depoſited, which is chiefly uric acid, and may be re-diſſolved by heating the urine.

When urine is expoſed to a gentle heat in an evaporating veſſel a ſteam ariſes, impregnated with an urinous odour, and a ſcum ariſes with many globules of gas entangled in it, which are chiefly carbonic acid.[d] As the evaporation advances the colour deepens to a dark red, and ſoon a whitiſh flocculent coagulum is depoſited, and the ſteam acquires an ammoniacal ſmell. At this period the exceſs of acid exiſting in recent urine is loſt, and on the contrary it turns ſyrup of violets green, which, together with the acquired ammoniacal ſmell, indicates the formation of a quantity of this alkali by the action of the heat. This circumſtance too has another effect, which is to precipitate the phoſphat of lime which was held in ſolution by the exceſs of acid, and the whitiſh coagulum conſiſts of this earthy ſalt, together with an animal matter of the nature either of gelatin or albumen, and of ſome urat of ammonia. When the evaporation is continued till the liquor has a ſyrupy conſiſtence, this, when decanted from the ſediment, and ſet in a cool place depoſits a conſiderable quantity of brown dirty cryſtals. To ſeparate the whole of theſe, the ſupernatant liquor ſhould be alternately evaporated and ſet by to cool, till the whole is brought nearly to dryneſs. By re-diſſolving all the foul cryſtals in warm water and again cryſtallizing, the ſalts may be obtained pure; but for the purpoſe of analyſis it is better firſt to digeſt the entire maſs, both cryſtals and reſidue, with good alcohol, which will not ſenſibly act on the ſalts, but will diſſolve the extractive matter with which they are mixed, and that of the reſidue, which conſiſts chiefly of the *urea*.

The ſalts conſiſt of the muriats of potaſh and ſoda, phoſphat of ſoda, and of the phoſphat of ſoda with ammonia, or *fuſible ſalt*. If after being rediſſolved, the ſolution is ſtrongly evaporated and ſet by to cool, a confuſed aſſemblage of cryſtals is formed, which was formerly conſidered without much diſtinction, as the native ſalt of urine. But if the ſolution is allowed to evaporate ſpontaneouſly, the muriats firſt ſeparate, after which ſmall cryſtals of phoſphat of ammonia are formed, and along with them larger cryſtals of ſimple phoſphat of ſoda, which latter may be diſtinguiſhed by their ſize, by their form of compreſſed four-ſided priſms, by effloreſcing, and by running into an opake glaſs when melted; whereas the pure phoſphat of ammonia when heated parts with its alkali, and a clear globule of phoſphoric acid is left. (For the further habitudes of theſe two ſalts ſee the article *Phoſphats*.)

The above ſimple method of analyſis therefore will give the following productſ: viz. 1ſt. a flocculent depoſit compoſed of uric acid, phoſphat of lime and a little albumen or gelatin: 2d. an alcoholic ſolution containing the proper extractive matter or urea: and 3d. a watery ſolution of the alkaline muriats and phoſphats. With regard to the relative proportions of theſe, Mr. Cruikſhank finds that 36 oz. of healthy urine may yield about 1 oz. of ſolid contents, of which he eſtimates the muriatic ſalts to be about 3 drams; the alkaline phoſphats to be 3 dr. 50 grs; the depoſit of phoſphat of lime and uric acid to be 25 grs; and the extractive matter or urea to be 3 drs. 40 grs.

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[b] Ann. Chim. tom. 31 & 32.

[c] Cruikſhank.

[d] Prouſt.

Some rough eſtimation of the relative proportions of the muriats and the phoſphats in the entire ſalt of urine may be made by heating them ſtrongly, by which if the muriats are very prevalent, the maſs will ſtrongly decrepitate and fuſe with difficulty; but if the phoſphats more abound the whole will readily run into thin fuſion. The uric acid and phoſphat of lime may be eaſily diſtinguiſhed by diſſolving them in dilute nitric acid and evaporating to dryneſs, by which the dry maſs when warm will aſſume a deep roſe colour, if the uric acid is preſent, and the ſolution will ſtain the fingers; but if only phoſphat of lime is preſent no ſuch effect will be produced. Calcination in a red heat will deſtroy the uric acid, and will leave the phoſphat of lime as a white friable maſs.

We ſhall purſue the analyſis of urine no further than to detail ſome of the effects of reagents upon urine, and the characteriſtic properties of urea.

Pure ammonia, and the fixed alkalies, and the alkaline earths dropped into healthy urine, produce a ſlight cloudineſs which ſettles into a precipitate of phoſphat of lime. This is owing to the neutralization of the acid which held it in ſolution as before explained.

Infuſion of galls or oak-bark gives a ſmall precipitate of tan, which amounts on an average to about 1 grain in an ounce of urine.

Muriat of barytes cauſes a copious denſe precipitate of phoſphat of barytes, which amounts to about 13 grs. from 4 oz. of healthy urine according to Mr. Cruikſhank, which is equivalent to about 24 grs. of microcoſmic ſalt.

Acetited lead produces a copious precipitate, which conſiſts of phoſphat and muriat of lead. Theſe may be ſeparated by digeſtion with about 20 parts of diſtilled water, which will diſſolve the muriat of lead and leave the phoſphat. The latter diſtilled with charcoal yields *phoſphorus*, as mentioned under that article.

We proceed to deſcribe the principal properties of the ſaponaceous extract of urine or *Urea*.

Mr. Cruikſhank had found that this was that part of the urine which peculiarly yielded carbonat of ammonia when diſtilled, and he has mentioned the following ſingular habitudes with nitric acid. If to one oz. of this extract be added as much nitrous acid diluted with an equal weight of water, a violent efferveſcence accompanied with the diſengagement of nitrous gas will take place, and when the action has ceaſed, and the liquor become cold, a number of ſhining cryſtalline ſcales reſembling the acid of borax, will be depoſited, which when dried on blotting paper will weigh about 6 or 7 drams, and will have the ſhape of flat rhomboids with a ſmooth greaſy feel. Theſe cryſtals are much more ſoluble in hot than in cold water; diſſolve in alcohol; have decidedly acid properties; and are readily diſſolved in ſulphuric and muriatic acid. Their ſolution in water does not render lime-water turbid, nor does it act upon acetite of lead, ſo that it is neither oxalic nor phoſphoric acid. When heated, this ſalt melts and evaporates in white ſmoke, and a reddiſh flame ſimilar to nitrat of ammonia.

To theſe diſtinguiſhing properties of urea, the reſearches of Fourcroy and Vauquelin have added the following: to obtain it in the greateſt purity, urine ſhould be evaporated ſlowly to dryneſs, and the reſidue digeſted with alcohol, which will leave moſt of the ſalts untouched, but will diſſolve the urea mixed with a little benzoic acid, from which it cannot well be ſeparated, but which is in ſuch ſmall quantity as not much to interfere with the properties of pure urea. If this alcoholic ſolution is evaporated to the conſiſtence of ſyrup and allowed to cool, the urea ſeparates in imperfect quadrangular plates, of a brilliant yellowiſh white, which alſo contain a little muriat of ammonia. In this ſtate it has an extremely fetid ſmell, ſtrongly adheres to the veſſel that contains it, is hard and granular, but highly deliqueſcent when expoſed to the air.

When urea is heated *per ſe* in a retort with a moderate fire, a white ſmoke firſt ariſes, which cryſtallizes in the neck of the receiver, and is benzoic acid. After this comes carbonat of ammonia, which alſo cryſtallizes, and this product continues unchanged to the end of the proceſs, without the production of any liquid, watery or oily. The veſſels are filled with an intenſely fetid ſmell, reſembling that of putrid fiſh. The reſidue in the retort is blackiſh and dry. If farther heated, white fumes of muriated ammonia riſe, and the carbonaceous reſidue exhales an odour of pruſſic acid when moiſtened. Urea is extremely ſoluble in water, and the ſolution when kept without addition does not eaſily alter, but on adding any albuminous matter it ferments, and acetite of ammonia appears in the liquid.

When the watery ſolution of urea is diſtilled, it is reſolved almoſt totally into liquid carbonat of ammonia, which is collected in the receiver.

The effect of nitric acid upon this ſingular ſubſtance has been already partly mentioned. The effervefcence produced by this acid is owing to the extrication of a vaſt quantity of azotic gas, mixed with carbonic acid.

The cauſtic fixed alkalies readily diſſolve urea, diſengage a good deal of ammonia from it, and the ſolution contains the benzoic, acetous, and carbonic acids, united with the alkali employed.

Another remarkable property of urea is the diſpoſition which it gives to muriat of ſoda mixed with it to cryſtallize in octohedrons, and muriat of ammonia in cubes; whereas the natural form of theſe ſalts is exactly the reverſe. Thus the common ſalt obtained in evaporating urine is always at firſt octohedral, but on calcining it to get rid of the urea, it appears on re-ſolution and cryſtallization in its natural cubic form. The like effect is produced by mixing cubical common ſalt with urea and cryſtallizing it, when it aſſumes the octohedral form.

This remarkable ſubſtance requires further examination.

The urea almoſt entirely diſappears from urine during that ſingular diſeaſe the *Diabetes Mellitus*, and a very large quantity of ſaccharine matter is produced, which latter may be extracted in abundance by evaporation and clarification, and has actually been brought to a very cloſe reſemblance of Muſcovado ſugar, and by digeſtion with nitric acid, yields a large quantity of oxalic acid.

V

VARNISHING[a], and LACQUERING, the art of.

A varniſh, in the moſt extenſive application of the term, is any fluid, which when ſpread thin upon a ſolid ſubſtance adheres to it, and, becoming dry, forms upon its ſurface a ſhining coating impervious to the air, and to moiſture.

In treating of this ſubject the moſt convenient method of arranging it will be according to the nature of the menſtrua from which the different varniſhes derive their fluidity. Theſe menſtrua are three in number, namely alcohol, eſſential oil, and fat oil.

The ſolid ſubſtances which by ſolution in the above menſtrua compoſe the body of the different varniſhes are the following.

1. Benzoin.

This ſubſtance is uſed in compound alcoholic varniſhes, chiefly on account of its fragrant odour: by itſelf it forms a tenacious but ſoft varniſh, which requires the addition of ſome of the harder reſins.

2. Lac.

This is one of the moſt uſeful ingredients in alcoholic varniſhes, it forms a body of great toughneſs and hardneſs: the only objection to it is its colour, which is a browniſh red.

3. Maſtich.

This is a reſin of prime importance to the varniſher; if well ſelected it has ſcarcely any colour, and poſſeſſes both toughneſs and hardneſs in a very conſiderable degree.

4. Anime.

This reſin is employed in ſome compound alcoholic varniſhes, chiefly on account of its agreeable odour.

5. Elemi.

Of this reſin there are two ſorts, the Ethiopian and South American. The former is greatly preferable to the latter; it is of a ſolid but tough conſiſtence, a greeniſh colour, and poſſeſſes an odour reſembling that of fennel: it communicates to the compound varniſhes great toughneſs and durability.

6. Sandarach.

This reſin communicates remarkable ſplendour to alcoholic varniſhes, but on account of its ſoftneſs requires to be mixed with the harder and tougher reſins.

7. Turpentine.

Almoſt all the different varieties of turpentine are employed by the varniſher: they afford gloſſineſs and body at ſmall expence, but require the admixture of ſome of the harder reſins.

8. Gamboge. 9. Dragon's blood.

Theſe are never employed by themſelves, but are uſed in ſmall proportions for the purpoſe of colouring compound varniſhes, eſpecially thoſe uſed in lacquering.

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[a] Tingry on Varniſhing—Handmaid to the Arts—Imiſon's Elements of Science and Arts. Vol. II.

10. Copal.

This valuble ſubſtance is employed in all the three kinds of varniſh, to which it communicates an uncommon degree of hardneſs.

11. Amber.

This is alſo a very valuable ingredient, but its application is principally confined to the coloured and opake oil varniſhes.

12. Aſphaltum.

This bitumen is extenſively uſed in the beſt black oil varniſhes.

13. Caoutchouc.

This ſubſtance is uſed only in the oil varniſh with which balloons are covered.

§. 1. *Alcoholic varniſhes.*

Alcoholic varniſhes are prepared with leſs trouble than others, they are eaſily applied, they ſoon dry, and are entirely free from any diſagreeable odour; on this account they are in very general eſtimation. They are however in return, very liable to crack, or ſcale off, and are incapable of reſiſting blows or long continued friction.

The compoſition of theſe varniſhes, though upon the whole ſufficiently ſimple, requires a few precautions which we ſhall proceed to mention. In the firſt place, care ſhould be taken not to add more reſin than the ſpirit can take up; for moſt reſins, however homogeneous they may appear to be, conſiſt of parts unequally ſoluble in alcohol; the conſequence of a ſuperfluity of reſin therefore will be, that the moſt ſoluble parts alone will be taken up, and the reſulting varniſh will be found to be much ſofter and leſs durable than if only ſuch a quantity of reſin was added as juſt ſufficed to ſaturate the alcohol. Indeed the very beſt way of proceeding is to add the reſin by ſmall portions at a time, taking care not to add a freſh quantity till the whole of the preceding is taken up.

Secondly, a mixture of two or more reſins is ſoluble in a leſs quantity of alcohol than would have been required for the ſolution of each ſeparately. This is particularly the caſe with thoſe compounds into which copal or ſandarach enter; theſe ſubſtances, eſpecially the former, being but very ſparingly ſoluble by themſelves in alcohol.

Thirdly, much depends upon the purity of the alcohol. If diluted to a certain degree with water it is incapable of acting even on the ſofteſt reſins; and for copal varniſhes the higheſt poſſible degree of rectification is abſolutely eſſential. The addition of camphor ſingularly facilitates the ſolution of copal and the more intractable reſins, but if uſed in too great a proportion it makes the varniſh mealy, and diminiſhes its tenacity.

Fourthly, during the ſolution of the reſins it is expedient that they ſhould expoſe as large a ſurface as poſſible to the action of the ſpirit; for it not unfrequently happens, eſpecially when heat is applied, that the reſins run together into a tough maſs, after which their ſolution goes on very ſlowly: this inconvenience may be obviated by mixing the reſins with rather coarſely pounded glaſs.

The following are ſome of the moſt approved receipts for alcoholic varniſhes.

1. Take of clean maſtich 6 ounces; and of ſandarach 3 ounces, and reduce the mixture to fine powder in a clean Wedgwood mortar: to this add 4 ounces of coarſely pounded glaſs, and pour the mixture into a three pint flaſk containing a quart of highly rectified alcohol: ſtop the flaſk looſely with a cork, and let the ingredients digeſt together in a warm room for three days, ſhaking the mixture frequently in the interval. Then melt three ounces of very clear Venice turpentine, by putting it into a cup ſet in hot water, and as ſoon as it is perfectly liquefied pour it into the alcoholic ſolution, alſo previouſly warmed, and then digeſt the whole in hot water for two hours; ſtirring it up frequently with a rod of glaſs, or a ſtick of white wood. When the digeſtion is finiſhed let the flaſk ſtand quiet for about a week in a warm room, and after that ſtrain the varniſh into a bottle through a little cotton wool.

2. Take of copal that has been liquefied, and afterwards very finely pounded, 3 ounces, of clean maſtich 3 ounces, of gum ſandarach 6 ounces, and of pounded glaſs 4 ounces: mix the ingredients with a quart of alcohol and digeſt them as already directed: then add 2½ ounces of clear turpentine.

This is a ſtrong and durable varniſh which may be applied to chairs and other articles of furniture.

3. Take of ſandarach 4 ounces, of ſeed lac 2 ounces, of maſtich 2 ounces, and of elemi 1 ounce; digeſt the whole in a quart of alcohol moderately warm, and when the ſolution is compleat add 2 ounces of Venice turpentine. This forms a good varniſh for violins and other muſical inſtruments.

4. Take of ſeed lac 8 ounces, and digeſt it for three or four days in a warm place with a quart of alcohol; when the ſolution is compleat ſtrain it through flannel to ſeparate the impurities, and the clarified liquor is the common lac varniſh.

5. Take of maſtich half an ounce, of white frankincenſe a quarter of an ounce, of ſandarach half an ounce, of benzoin half an ounce, and diſſolve the ingredients in a pint of highly rectified alcohol: a colourleſs varniſh is thus formed, which is employed for defending the ſilvering of clock-faces, of barometer ſcales, and other ſimilar articles, from the action of the air.

6. Take of ſandarach 6 ounces, of elemi 4 ounces, of anime 1 ounce; pound the whole together, and then add 4 ounces of coarſely pulverized glaſs: infuſe the mixture in a quart of rectified alcohol, and add at intervals as the ſolution goes on half an ounce of camphor. The reſult is a very good colourleſs varniſh for boxes of *papier maché* and ſimilar articles.

7. A ſimilar varniſh to the above but ſomewhat coarſer, is compoſed of white frankincenſe 6 ounces, anime and elemi of each two ounces, pounded glaſs 4 ounces, and a quart of alcohol.

§. 2. *Eſſential Oil Varniſhes.*

The high price of moſt of the eſſential oils is ſuch as to preclude the varniſher from the uſe of them; oil of lavender is occaſionally employed, but the uſual menſtruum is oil of turpentine. The purity of this latter fluid is of the utmoſt importance: that which is commonly ſold at the oil and colour ſhops, though ſufficiently pure for oil painting, will very rarely anſwer the purpoſe of the varniſher, who if he wiſhes to ſave himſelf from much mortification and diſappointment will apply for this article to Apothecaries' Hall, London, where it is conſtantly to be procured in the utmoſt purity.

Varniſhes with oil of turpentine and the reſins are ſomewhat ſofter but conſiderably tougher than thoſe prepared with alcohol; hence they are not ſo liable to crack and ſcale off. They are principally uſed for varniſhing oil paintings, for mixing up colours with, and for lacquering. A compoſition applicable to the firſt of theſe purpoſes is the following.

8. Take of pure and waſhed maſtich 12 ounces, and of pounded glaſs 5 ounces, infuſe the mixture in a quart of pure oil of turpentine, adding at intervals half an ounce of camphor in ſmall pieces; when the maſtich is diſſolved add to the warmed fluid an ounce and a half of clear turpentine previouſly melted, and ſtir the mixture together till it is thoroughly incorporated.

Several of the copal varniſhes may be alſo arranged under this ſection, eſpecially thoſe that are beſt fitted for varniſhing articles of wood and paſteboard. Several of theſe have been already deſcribed under the article Copal, to which we refer the reader. To thoſe may be added the following very ſimple and very efficacious one.

9. Take from 3 to 4 ounces of copal that has previouſly been liquefied in as gentle a heat as poſſible, and 20 ounce meaſures of the pureſt oil of turpentine; put this latter in a mattraſs ſet in boiling water, and add the pulverized copal in ſmall quantities at a time, in proportion as it is diſſolved. If the materials are good, and the proceſs well conducted, ſomewhat more than 3 ounces of copal will be taken up, and the liquid will be a little cloudy: by ſtanding for a few days it will become clear, and ſhould then be ſtrained through cotton. This is a thick varniſh, and will generally require to be diluted with a little warm oil of turpentine before it can be uſed: it forms a very hard and durable glazing, which will dry in ſummer in the ſpace of two or three days, or in a leſs time if put into a warm ſtove.

§. 3. *Fat Oil Varniſhes.*

Theſe are tougher and leſs liable to crack than the preceding, and by expoſure to a proper degree of heat may be made to acquire a very great hardneſs: they are however very long in drying without the aſſiſtance of a ſtove, and give out an extremely diſagreeable odour during drying: they are alſo for the moſt part high coloured, and are therefore ſeldom uſed by themſelves, but mixed up with ſome opake body colour. The materials employed in the compoſition of theſe varniſhes, with the exception of mere colouring ſubſtances, are the following, copal, amber, aſphaltum, drying oil, and oil of turpentine.

The moſt colourleſs of the fat varniſhes is thus prepared.

10. Take of copal liquefied, according to Tingry's method, and finely pulverized, 4 ounces, of drying linſeed oil and oil of turpentine, each 10 ounces; put the whole into a mattraſs, and apply a very gentle heat till the copal is diſſolved: this being done, let the varniſh ſtand for a few days to clear, and afterwards ſtrain it through cotton. This forms a ſolid and nearly colourleſs glazing, and dries eaſily at the common temperature.

11. Take of picked copal 16 ounces, and melt it in a clean iron pot with as gentle a heat as poſſible, when its fuſion is compleat, pour in 3 ounces of drying linſeed oil boiling hot, and incorporate the ingredients by ſtirring; then remove it from the fire, and while it is yet

warm pour in a pint of oil of turpentine, alſo warm; ſtrain the varniſh before it gets cold through a piece of linen, and bottle it. The older it is before being uſed the better. This is a very valuable varniſh though higher coloured than the preceding; when dried carefully in a ſtove it becomes very hard. Amber varniſh is reckoned harder than copal varniſh, on which account it is preferred for ſome works, it has the diſadvantage however of being much deeper coloured. To prepare this varniſh,

12. Take of amber coarſely pounded 16 ounces, and melt it in a clean iron pot, then add to it 2 ounces of melted lac and 10 ounces of drying oil boiling hot; incorporate the whole accurately by ſtirring, then remove it from the fire, and add a pint of warm oil of turpentine.

The beautiful black varniſh uſed by the coach-makers is thus prepared.

13. Take of amber 16 ounces, and melt it in a clean iron pot, then add to it half a pint of drying linſeed oil boiling hot, and 3 ounces of roſin, and the ſame quantity of aſphaltum, each in fine powder, ſtir the materials together till they are thoroughly melted and incorporated together; then remove the varniſh from the fire, and add to it a pint of warm oil of turpentine.

The above oil varniſhes are intended to dry to a very hard conſiſtence: thoſe however that are employed for making ſilk and linen water and air tight are required to be tough, without any degree of hardneſs. A varniſh of this kind, which was firſt applied to balloons, is thus compoſed.

14. Take of the beſt oil of turpentine 3 ounces, and of caoutchouc in ſlips a third of an ounce; put the whole in a cloſe corked bottle, and keep it at the uſual temperature for three or four days, in which time the caoutchouc will for the moſt part be diſſolved, forming a tenacious thick fluid; pour this into a pint of drying linſeed oil, and heat the mixture for a few minutes nearly to boiling, then take it from the fire and ſtrain it while warm through a piece of linen. This is a very effectual varniſh, but it is long in drying. The following therefore is to be preferred.

15. Take of very drying linſeed oil half a pint, and of birdlime 1 pound, put the mixture in an iron pot, and heat it nearly to boiling, till the birdlime ceaſes to crackle, then pour in 2½ pints more of drying oil, and boil it for about an hour with conſtant ſtirring, taking care that it does not boil over. When it has acquired ſo much tenacity that a little rubbed between two knife blades will draw out into threads on the ſeparation of the blades from each other, it may be removed from the fire, and well mixed with a quart of oil of turpentine, and then ſtrained and bottled. In order to apply it, the ſilk or linen muſt be quite dry and the varniſh lukewarm; a thin coat is to be firſt laid on on one ſide, and about twelve hours after two other coats ſhould be laid on one on each ſide, and in twenty-four hours after the ſtuff will be dry enough to be uſed.

§ 4. *Of Lacquers.*

A lacquer is a tranſparent varniſh applied to the ſurface of metals, both for the purpoſe of protecting them from the action of air and moiſture, and for heightening their colour and bringing it nearer to that of gold. The metals that are commonly lacquered are braſs and tin. The following are ſome of the beſt varniſhes for the purpoſe.

17. Take of turmeric pulverized 1 ounce, and of ſaffron and arnotta each 2 drachms; infuſe them at a moderate temperature for a week or more in a pint of rectified alcohol: ſeparate the yellow tincture thus obtained, by ſtraining through a piece of clean linen, and add to the clear liquor three ounces of good ſeed lac: let the materials digeſt together for ſome days in a bottle, with frequent ſhaking, and then ſtrain off the clear part, which is the lacquer. If the piece of braſs to which it is to be applied is large, as a lock for example, it is to be warmed, and the lacquer alſo warm is to be ſpread on with a bruſh; if the articles are ſmall they are to be made up into packets, then warmed and afterwards dipped into the varniſh.

Another lacquer for braſs ſtill cheaper than the foregoing, and nearly as good, is made by ſubſtituting half a drachm of the beſt dragon's blood inſtead of the ſaffron and arnotta.

The following varniſh may be applied to lamps and other articles of tinned ware, in order to make them reſemble braſs.

18. Take of turmeric one ounce, and of dragon's blood two drachms; infuſe the ingredients in a pint of alcohol, and when the tincture is compleated, ſtrain it through a piece of clean linen, and add to the clear liquor three ounces of ſeed lac; in a few days the ſolution will be compleated, after which the varniſh is to be ſtrained and is then fit for uſe.

One more lacquer remains to be mentioned, namely that which is employed in the preparation of gilt leather as it is called. The appearance of gilding is produced on leather by fixing upon it, by means of ſtrong ſize, very highly burniſhed tinfoil or ſilver leaf, and then coating the poliſhed ſurface over with the following varniſh.

19. Take of fine white reſin 4½ lbs. of common reſin the ſame quantity, of gum ſandarach 2½ lbs. and of common aloes 2 lbs.: melt the whole over a gentle fire, ſtirring them well at the ſame time with an iron ſpatula; when the fuſion is compleat add by degrees 7 pints of linſeed oil, and make the whole boil for ſix or ſeven hours, ſtirring it carefully all the time. When the varniſh begins to get ropy, ſtir in half an ounce of red lead finely pulverized: as ſoon as this latter is compleatly diſſolved remove the varniſh from the fire and ſtrain it while warm through a linen or flannel bag.

VEGETABLE MATTER.

Having already noticed at length in their proper places the different vegetable principles, and ſuch individual vegetable ſubſtances as have received any thing like an accurate chemical analyſis, there remain but a few words to be ſaid on the general ſubject.

Vegetable matter, though in its ultimate analyſis it is compoſed for the moſt part of oxygen, hydrogen, carbon, and azot, is made up of a number of ſecondary compounds, which we ſhall proceed to enumerate.

The moſt important of all, if we have regard to its quantity, in which it greatly exceeds all the reſt put together, is *vegetable fibre* or *Wood.* This is to plants what bone, muſcle, and cartilage are to animals; to this they are entirely indebted for their ſtability and the reſiſtance which they are able to oppoſe to external violence: it conſtitutes the greater part of all woods and barks; of the green epidermis of herbaceous plants, of the network of leaves, and of the fine downy fibres in which the ſeeds of cotton and various other vegetables are imbedded. It conſiſts of carbon, oxygen, hydrogen, and a little azot. By dry diſtillation it yields hydro-carbonous gas, carbonic acid, empyreumatic acetous, or pyroligneous acid, with a little ammonia, and a little volatile oil; a large proportion of charcoal remains behind in the retort, ſtill exhibiting in a very perfect manner the texture of the wood. There is no animal ſubſtance at all analogous to vegetable fibre.

The next perhaps in quantity is *fecula* or ſtarch. It is contained in all ſeeds, and more ſparingly in moſt of the bulbous, tuberous, and other fleſhy roots. It is not aſcertained whether azot enters into its compoſition; it certainly however affords no ammonia by dry diſtillation. It appears to be abſolutely peculiar to the vegetable kingdom.

Extract is another of the peculiar vegetable principles; but though nothing analogous to it exiſts in the animal kingdom, yet it affords ammonia both by dry diſtillation and by the action of quicklime; in the former caſe indeed the ammonia is maſked by the contemporaneous production of empyreumatic acid, but it may readily be ſet at liberty by means of the fixed alkalies.

Another vegetable principle is *Tannin:* it is contained in certain barks, woods, and leaves, and affords by dry diſtillation an empyreumatic acid but no ammonia. It may be conſidered as peculiar to vegetables, although it appears from Mr. Hatchett's experiments that a ſubſtance very ſimilar to tannin may be procured by the action of nitric acid on various kinds of animal matter previouſly charred.

Gum mucilage is another of the peculiar vegetable principles to which nothing analogous has yet been diſcovered in the animal kingdom: it reſides chiefly in the barks of trees, and in a few of the bulbous roots. By dry diſtillation it affords an empyreumatic acid, from which however quicklime ſets at liberty a quantity of ammonia, thus ſhowing that azot enters into the compoſition of this ſubſtance.

Volatile oil is alſo peculiar to the vegetable kingdom: it occurs in the bark, the wood, and the covering of ſeveral ſeeds: it appears to conſiſt entirely of oxygen, hydrogen, and carbon: it does not afford any ammonia by diſtillation.

Camphor, *Reſin*, and *Balſam* alſo rank among the peculiar vegetable principles, and appear to conſiſt of oxygen, hydrogen and carbon, without any azot. A few of the aromatic animal products indeed, ſuch as muſk, civet and ambergris appear to contain a portion of reſin, which however differs from vegetable reſin in affording ammonia by digeſtion with fixed alkali, and therefore contains azot.

Gum reſin, *Gluten* and *Caoutchouc*, are three peculiar vegetable principles, into the compoſition of which a conſiderable quantity of azot enters, as they afford ammonia and oil by dry diſtillation, but no acid.

The acids peculiar to vegetables are the *tartaric*, *citric* and *gallic*, the *malic*, *oxalic*, *acetic* and *pruſſic*; of theſe however the four latter, though not originating in animal organization, may yet be produced by the action of different re-agents on ſeveral animal products.

The ſubſtances common to both vegetable and animal matter are the following, viz.

Sugar. This is contained largely in the ſtems of ſome of the graſſes, in the nectaries of all bloſſoms, in the pulp of certain fruits, and in many of the fleſhy ſpindle-ſhaped roots; alſo in the milk of animals, and in human urine in a peculiar diſeaſed ſtate. It is much more abundant in the vegetable than in the animal kingdom, and by deſtructive diſtillation affords a large proportion of empyreumatic acid but no ammonia.

Fixed oil: This is contained in moſt ſeeds, and in the pulpy fruit of the olive, the cornel, and perhaps of a few other plants: in animals it reſides in the liver, in cellular membrane, and in milk: it appears to conſiſt of oxygen, hydrogen and carbon, with little or no azot, and affords an acid by deſtructive diſtillation.

Albumen, *Fibrin* and *Gelatin:* theſe ſubſtances are of extremely rare occurrence in the vegetable kingdom, but they conſtitute almoſt the whole of the ſoft parts of animals: they are compoſed for the moſt part of oxygen, hydrogen, carbon and azot, and afford by diſtillation ammonia and oil, but no acid.

Benzoic and *phoſphoric* acids: of theſe, the former is found in the vegetable balſams, and in the urine of the horſe, and of a few other quadrupeds: the latter, combined with lime, is very abundant in animals, conſtituting the principal portion of the bones and other hard parts; but is of comparatively rare occurrence in vegetables, in which it is found in combination with lime or potaſh.

All the above vegetable principles may be ultimately reſolved into the following 15 ſubſtances, viz. oxygen, carbon, hydrogen, azot, ſulphur, phoſphoric and muriatic acids, oxyds of iron and manganeſe, potaſh and ſoda, lime, magneſia, ſilex and alumine, and of theſe the four firſt conſtitute by far the largeſt maſs of vegetable matter.

As all animal matter is prepared by the proceſs of digeſtion from vegetables, it is obvious that each of theſe great claſſes of ſubſtances muſt exhibit in its ultimate analyſis the ſame ſimple ſubſtances. It is moreover evident from the preceding enumeration that not only the elements, but many of the ſecondary principles derived from them are common both to vegetables and animals, and therefore that ſtrictly ſpeaking there can be no eſſential characters by which the chemiſt can pronounce deciſively concerning any unknown ſubſtance preſented to his examination, that it belongs to the animal or vegetable kingdom. The old chemiſts indeed relied with confidence on the phenomena afforded by deſtructive diſtillation: if an ammoniacal liquor was produced accompanied by the odour of burnt feathers, the ſubſtance yielding it was preſumed to be of animal origin; whereas if an acid liquor was produced accompanied by the odour of wood-ſmoke, the unknown ſubſtance was conſidered as belonging to the vegetable kingdom, and this, though by no means an infallible criterion, muſt ſtill be conſidered as the beſt that can be adopted.

VENUS, cryſtals of } See COPPER.
VERDITER }

VERMILLION. See MERCURY.

VESUVIAN. *Volcanic Schorl*, *Volcanic Chryſolite*, *Veſuvian Hyacinth.*—*Idocraſe.* Hauy.

Its colour is yellowiſh-brown, paſſing into olive and leek-green, clove-brown, and fleſh and hyacinth red.

It occurs in maſs, diſſeminated, or cryſtallized. The forms of its cryſtals are,

1. A ſtrait four-ſided priſm truncated on the edges and ſometimes on the ſolid angles; when the priſm is ſhort, the whole figure approaches near to the cube, and is occaſionally even tabular.

2. A ſtrait octohedral priſm terminated by tetrahedral pyramids with truncated ſummits.

3. A hexahedral priſm with ſingle and ſometimes double truncatures on the lateral edges, ſo as to give the cryſtal a cylindrical appearance.

The cryſtals are middle-ſized or ſmall, and are either ſolitary or in groups, or in druſes; the lateral faces are ſlightly ſtriated longitudinally, the others are ſmooth. Externally it has a brightly ſhining vitreous luſtre; internally its luſtre is gliſtening and unctuous. Its fracture is imperfectly conchoidal paſſing into fine granular and lamellar. It is uſually more or leſs tranſlucent; is hard, brittle, and eaſily frangible. Sp. gr. 3.36 to 3.42.

It fuſes before the blow-pipe without addition into a yellowiſh-green glaſs. When ſtrongly heated in a charcoal crucible, it forms a denſe clear nearly colourleſs glaſs, with imbedded grains of iron: in a clay crucible it affords a dark olive green glaſs of conſiderable luſtre.

Specimens both from Veſuvius and Siberia have been analyſed by Klaproth with the following reſults.

Veſuvius.		Siberia.	
35.5	—	42.	Silex
33.	—	34.	Lime
22.25	—	16.25	Alumine
7.5	—	5.5	Oxyd of iron
0.25	—	a trace	Ditto of manganeſe
98.5	—	97.75	

It occurs in the lava of Veſuvius accompanied by granular limeſtone, felſpar, mica, hornblende, zeolite, garnet, &c. The Siberian variety is found in Kamtſchatka, at the mouth of the river Achtaragda, imbedded in ſteatite, and accompanied by magnetic iron.

VESUVIAN (of Kirwan). See Leucite.

VINEGAR. *Eſſig*, Germ.

Vinegar is a liquor of an agreeable ſmell, a pleaſant and ſtrongly acid taſte, and of a hue varying from light red to brown ſtraw colour, and is prepared by fermenting any ſubſtance or compound which has already undergone the ſpirituous fermentation. Vinegar therefore may be made immediately from any wine, malt liquor, cyder, &c. or from the juice of the grape and other fruits, from infuſion of malt, or any ſaccharine liquid, through the intermedium of vinous fermentation. Both theſe methods are actually practiſed with compleat ſucceſs.

The chemical properties of the pure acid of the different kinds of vinegar (which appears to be the ſame in all) have been already deſcribed under the article Acetous Acid, and we ſhall therefore only mention the uſual proceſſes of manufacture.

To make vinegar out of a liquor containing ſuitable materials, it is only neceſſary, 1ſt. to allow ſome acceſs of air to the veſſel in which it is kept, and 2d. to keep it in a temperature rather higher than that of the atmoſphere in this climate, that is to ſay, about 75° to 80°. It is alſo almoſt eſſential where a liquor already fermented is employed, to add a portion of yeaſt, or any other ferment, for though any fermented liquor if kept in a moderate temperature in an open veſſel will ſpontaneouſly run ſour or become changed to vinegar, this change is too gradual to produce this acid in perfection, and the firſt acetified portion turns mouldy before the laſt has become ſour. But where the ſubſtance employed has not yet undergone fermentation, the whole proceſs of the vinous and ſubſequent acetous fermentation will go on uninterruptedly with the ſame ferment which at firſt ſet it in action, which happens, for example, in the making vinegar from malt or from ſugar and water.

As even vinegar is not the ultimate change which a vinous liquor ſpontaneouſly aſſumes, there is a period in the proceſs of the manufacture in which the acid is in its higheſt degree of ſtrength and perfection, after which if the proceſs is not ſtopped, the liquor ſpeedily deteriorates, the acetous acid gradually diſappears, and only an offenſive mouldy watery liquid remains, with ſcarcely any ſourneſs. It belongs therefore to the ſkill and experience of the manufacturer to know when his vinegar is compleat and fit to be drawn off and cloſely barrelled.

Vinegar was doubtleſs (as its name imports) originally made from wine, and this is the material which furniſhes it probably in the greateſt perfection, and is employed ſolely in the wine countries. It is prepared by adding wine lees to wine, which excites a new fermentation that is kept up till the whole is changed to vinegar. Any wine will anſwer the purpoſe; the beſt and fulleſt-bodied wine gives the ſtrongeſt vinegar, and that which is already ſoured and injured by keeping may be applied to this uſe. The actual method purſued in Paris is the following.[a] A quantity of wine lees is put into a large tun, and worked up with wine ſufficient to render it very fluid. This is then put into cloth ſacks, which are arranged in a large iron-bound wooden vat, the heavy cover of which is laid over them and ſerves as a preſs, that is gradually ſcrewed down till all the liquor is preſſed out. The wine, thus loaded with the extractive and tartareous matter of the lees, is diſtributed in large caſks ſet upright, through the heading of which a hole is cut which is conſtantly left open. In ſummer theſe caſks are ſimply ſet in the ſun, but in winter they are arranged in a ſtoved room. The fermentation comes on in a day or two, and when it has got to its height ſo much heat is excited that ſometimes the hand can hardly be borne in it. In this caſe it muſt be checked by a cooler air, and by adding ſome freſh wine to the caſks, and indeed it is in a due regulation of the heat that moſt of the practical ſkill of the maker conſiſts. The proceſs goes on in this way till the whole of the wine is thoroughly acidified, which requires about a fortnight in ſummer and a month in winter; after which the new vinegar is put into barrels, at the bottom of which are laid a good many chips of beech wood. Here it remains for about a fortnight, during which time it clarifies and the clear part is then drawn off and kept in well cloſed caſks. Theſe beech chips may be uſed over and over again for ſeveral years.

The natural colour of good wine vinegar is a very pale red, but a higher colour is given, if deſired, by the addition of elder-berries.

There are ſeveral ſlight variations in the mode of making wine vinegar, but which need not be detailed. They all conſiſt in exciting a freſh fermentation in wine and keeping it up in a moderate degree till acetification is compleat. Many refuſe parts of the vine are of uſe for this purpoſe, ſuch as the huſks, the four ſucculent twigs, the marc or cake left in the wine preſs, and the like; and after they have once ſerved, they are ſtill more valuable, as the acid which they naturally contain, or which is evolved by them, is more readily produced.

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[a] Encycl. Arts & Met. Article Vinaigre.

Wine may alſo be converted to good vinegar without theſe additions, ſimply by adding wine, eſpecially when on the fret, to vinegar already made, and expoſing it to a proper heat. In this way many manufacturers proceed, keeping their caſks always full by taking out of them at intervals about a third or fourth part, repleniſhing them with wine, and again bringing the contents to the ſtate of vinegar.

In this country vinegar is chiefly made from malt. The following is the uſual proceſs in London. A maſh of malt and hot water is made, which after infuſion for an hour and a half is conveyed into a cooler a few inches deep, and thence, when ſufficiently cooled, into large and deep fermenting tuns, where it is mixed with yeaſt and kept in fermentation for four or five days. The liquor (which is now a ſtrong ale without hops) is then diſtributed into ſmaller barrels ſet cloſe together in a ſtoved chamber and a moderate heat is kept up for about ſix weeks, during which the fermentation goes on equally and uniformly till the whole is ſoured. This is then emptied into common barrels, which are ſet in rows (often of many hundreds) in a field in the open air, the bung-hole being juſt covered with a tile to keep off the wet but to allow a free admiſſion of air. Here the liquor remains for four or five months, according to the heat of the weather, a gentle fermentation being kept up, till it becomes perfect vinegar. This is finiſhed in the following way. Large tuns are employed, with a falſe bottom, on which is put a quantity of the refuſe of raiſins or other fruit left by the makers of raiſin and other home-made wines, called technically *rape*. Theſe rape tuns are worked by pairs; one of them is quite filled with the vinegar from the barrels, and the other only three-quarters full, ſo that the fermentation is excited more eaſily in the latter than the former, and every day a portion of the vinegar is laded from one to the other till the whole is completely finiſhed and fit for ſale.

Vinegar, as well as fruit-wines, is often made in ſmall quantity for domeſtic uſes, and the proceſs is by no means difficult. The materials may be either brown ſugar and water alone, or ſugar with raiſins, currants, and eſpecially ripe gooſeberries. Theſe ſhould be mixed in the proportions which would give a ſtrong wine, put into a ſmall barrel, which it ſhould fill about three-fourths, and the bung-hole very looſely ſtopped. Some yeaſt, or, what is better, a toaſt ſopped in yeaſt ſhould be put in, and the barrel ſet in the ſun in ſummer, or a little way from a fire in winter, and the fermentation will ſoon begin. This ſhould be kept up conſtant but very moderate, till the taſte and ſmell indicate that the vinegar is compleat. It ſhould be poured off clear and bottled carefully, and it will keep much better if it is boiled for a minute, cooled and ſtrained before bottling.

Vinegar contains a conſiderable quantity of colouring extractive matter, from which it can only be freed by diſtillation, the proceſs of which, together with the chemical properties of this acid, have been mentioned under the article *Acetous Acid.*

When vinegar is long kept, eſpecially expoſed to the air, it becomes muddy, acquires a mouldy unpleaſant ſmell, loſes its clear red colour and all its properties, and finally is changed to a ſlimy mucilage and water.

VITAL AIR. See OXYGEN.

VITRIFICATION. See GLASS.

VITRIOL, native. *Naturlicher Vitriol.* Wern.

Its colour is greyiſh or yellowiſh-white, apple or verdigris-green, or ſky-blue; when decompoſing it is covered with an ochery cruſt. It occurs in maſs, diſſeminated, ſtalactitical and capillary. Externally it is rough and dull, internally it is more or leſs ſhining, with a vitreous or ſilky luſtre. Its fracture is generally fine and ſtrait fibrous, ſometimes alſo lamellar or conchoidal. It is ſoft, brittle, tranſlucent, and has an acerb metallic flavour. It is more or leſs ſoluble in water, and is a mixture in various proportions of the ſulphats of iron, copper, and zinc.

It not unfrequently occurs in caverns and ſhafts, in argillaceous ſchiſtus, and in old mines, eſpecially ſuch as abound in blende and pyrites.

VITRIOL blue. See COPPER, Sulphat of.

VITRIOL green. See IRON, Sulphat of.

VITRIOL white. See ZINC, Sulphat of.

VITRIOLATED TARTAR. See SULPHAT of Potaſh.

VITRIOLIC ACID. See SULPHURIC ACID.

VOLATILE ALKALI. See AMMONIA.

W

WAKKE.

Its colour is generally a deep greeniſh-grey, paſſing to greeniſh and greyiſh black; it is alſo not unfrequently ſpotted reddiſh or browniſh. It occurs in maſs and cellular; the cells being either empty or filled with other minerals. Internally it is dull. Its fracture is even, paſſing into uneven and earthy. Its fragments are indeterminate and blunt-edged. It is opake, acquires a little luſtre by friction, is ſoft and eaſily frangible; it is ſomewhat unctuous to the touch. Sp. gr. 2.53 — 2.89. It is readily fuſible by itſelf before the blow-pipe into a black glaſs.

It belongs to the more recent of the rocks of trap-formation, and not unfrequently incloſes petrified wood and other organic remains. It occurs in beds, and veins, and forms the baſe of many of the amygdaloids.

The cavities in the cellular variety generally contain green earth, calcareous ſpar, &c. It is often mixed with cryſtals of baſaltic hornblende, with black mica, magnetical iron ore, and native biſmuth.

For further particulars ſee Trap.

WALKERERDE. See Fuller's Earth.

WATER. *Eau*, Fr. *Waſſer*, Germ.

Water at the common temperature is a perfectly tranſparent inelaſtic fluid, of a very pale bluiſh-green colour when in large maſſes, and entirely deſtitute of flavour and odour. In ordinary circumſtances it retains its liquid form only between the two extremes of 32° and 212° of Fahrenheit's thermometer, but when ſubjected to great preſſure, as in Papin's digeſter, it is able to ſuſtain nearly a red heat without being converted into ſteam: and on the other hand when the preſſure of the atmoſphere is removed, by incloſing it in an exhauſted receiver, it is convertible into elaſtic vapour by a temperature hardly exceeding 70°. Its point of congelation alſo may be protracted, by cautiouſly cooling it down without agitation, to about 22°; but at this temperature a ſlight friction is ſufficient to determine the inſtant ſolidification of the maſs, which is attended by a very ſenſible evolution of heat, as we have ſhewn at large in the article Caloric. Water, like other inelaſtic fluids is nearly though not abſolutely incompreſſible. The ſpecific gravity of water at 60° is = 1.0, this liquid being univerſally adopted as that to which the ſpecific gravities of all other bodies are to be compared, and by which they are to be adjuſted. Other liquids increaſe in denſity by an uniform progreſſion according to the cold to which they are expoſed, but in water the period of greateſt denſity is at the temperature of 42° F. and from this point equal degrees, whether of cold or heat, produce equal changes of ſpecific gravity, ſo that water at 3[illegible]° and at 52° poſſeſſes the ſame degree of denſity. The abſolute weight of a cubic foot of water at 40°, appears from ſome very accurate experiments by Lefevre Gineau to be = 437102 grs. troy, or .999.09 ounces avoirdupois; and the weight of a like bulk of water at 55° is ſtated by Prof. Robiſon at 998.74 ounces avoirdupois. The weight of a cubic inch of water at the ſame temperature is = 253.03 grs. but according to the experiments of Sir G. S. Evelyn, as corrected by Mr. Fletcher, it is = 252.506. See the Appendix of *Weights and Meaſures*.

At 32° Fahr. as we have already mentioned, water becomes ſolid, and in doing ſo, aſſumes a true cryſtalline texture: if a flaſk of water be ſet in a moderate freezing mixture till a conſiderable part is frozen, and the fluid portion be then poured off, there will be perceived acicular cryſtals ſhooting from the maſs, and croſſing each other at angles of 60 and 120 degrees; ſometimes alſo, though rarely, there may be perceived tetrahedral priſms terminated by dihedral ſummits. Ice when at a low temperature is conſiderably hard, tough, and elaſtic: at the celebrated palace of ice conſtructed one winter at Peterſburgh by order of the late Empreſs Catharine, there were cannon made of this material, which ſuſtained ſeveral diſcharges without burſting. The ſpecific gravity of ice is conſiderably leſs than that of water, in conſequence of which it floats upon its ſurface; a part of this buoyancy, however, is to be attributed to the bubbles of air entangled in its ſubſtance, which are diſengaged by common water in the act of congelation. The expanſive force of water while converting into ice is ſo prodigious that its limits have not yet been aſcertained: the moſt intereſting experiments on this ſubject are thoſe performed by Major Williams at Quebec;[*] bomb-ſhells about 13 inches in diameter, and with a thickneſs of metal exceeding 2 inches, were filled with water; the fuſe holes were then plugged up with iron bolts, and the ſhells thus charged were expoſed to the open air at a temperature between — 4° and — 19°: at the moment of congelation the plugs were thrown out with a hiſſing noiſe to a diſtance of 300 or 400 feet, while a column of ice roſe at the ſame time through the fuſe hole to the heighth of ſeveral inches: when the plug was ſecured by ſtrong ſprings ſo as to render it almoſt impoſſible to force it out, the ſhell itſelf burſt with a ſudden crack, and two thin plates of ice forced their way at the ſame time through the aperture. The greateſt difference obſerved in theſe experiments between the bulk of water before and after congelation, was : 174 : 184.

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[*] Edin. Phil. Tranſ. Vol. II.

Water, under the ordinary atmoſpheric preſſure, is converted into ſteam, at 212° of temperature, and by ſo doing it expands to about 1800 times its former bulk: the elaſtic force which it thus acquires is very conſiderable, and conſtitutes the moving power of that moſt important machine, the ſteam engine. Steam readily and entirely condenſes into water as it cools, and it is in this way, that is by diſtillation, that pure water is obtained; for the moſt delicate chemical uſes, the diſtillation muſt be carried on in glaſs veſſels, and even with every poſſible precaution it is by no means eaſy to obtain this fluid of abſolute purity.

It does not appear that mere heat is capable of effecting any change in water, for ſteam may be paſſed through a red hot glaſs tube, and be condenſed at the other end again into pure water.

A conſiderable affinity ſubſiſts between water and atmoſpheric air; for if this fluid recently diſtilled be expoſed for a few days to the air, and afterwards be boiled or ſubjected to the action of the air-pump, a conſiderable quantity of bubbles of gas will be diſengaged; there ſtill however remains a portion combined with the water which it is very difficult to get rid of even by long boiling.

Oxygen gas is abſorbed by water in preference to atmoſpheric air, and by means of ſtrong agitation and preſſure according to the experiments of M Paul, of Geneva, 100 cubic inches of this fluid may be made to take up 50 cubic inches of oxygen gas, 33 cubic inches of hydrogen and 66 cubic inches of carburetted hydrogen. Water thus highly charged effervefces when the extraordinary preſſure is taken off, and in this ſtate has been uſed as a medicine. Any other of the permanent gaſſes may in like manner be combined with water, as we have mentioned when treating of theſe ſubſtances. For the proportions of different gaſſes which water at the common preſſure is capable of taking up, ſee the article GAS.

Water is capable of combining with and diſſolving the acids, the alkalies and alkaline earths, and all the compound ſalts; with ſeveral of theſe ſubſtances it unites in two proportions, forming in one caſe a ſolid, and in the other caſe a fluid compound; thus if calcined gypſum, or barytes, or lime, or ſulphat of ſoda, are mixed with a certain proportion of water, the reſulting maſs is quite as ſolid as before, and during this firſt combination a quantity of heat is conſtantly extricated, but if to the ſalts thus ſaturated more water is added, ſolution takes place, and cold is generated. From this ſolution the ſalt may again be in moſt caſes procured, by evaporation and cooling, in a cryſtalline form, in which, though ſolid, it is ſtill ſaturated with water: this proportion of water appears to be neceſſary to the cryſtalline form of the ſalt, and hence is uſually called its *water of cryſtallization*; by a dry heat it is driven off and the ſalt alone remains in a pulverulent or amorphous ſtate.

A conſiderable affinity ſubſiſts between water and alcohol: if determinate bulks of theſe two fluids be mixed together, the reſulting maſs will be found to have a ſpecific gravity ſuperior to that of the mean of the ingredients, and a ſenſible degree of heat will be diſengaged during mixture: there appears however to be no point of mutual ſaturation, as they will combine together in all proportions. Reſins and moſt other ſubſtances inſoluble in water, but ſoluble in alcohol, are precipitated from their ſolution by the addition of this latter fluid; as on the other hand all ſalts that are ſoluble in water but not in alcohol are precipitated by means of this from their watery ſolution.

Ether and water are capable of uniting in two different proportions. If equal bulks of the two fluids are ſhaken together, and then allowed to reſt for a few ſeconds, the maſs will divide into two diſtinct liquids, of which the upper and lighter is ether holding a little water, and the lower and denſer is water combined with a little ether. That ether ſaturated with water is chemically different from pure ether, appears from its being able to diſſolve caoutchouc, which this fluid when pure is incapable of doing.

None of the ſimple combuſtibles appear to be ſoluble in water, nor have they any marked action on this fluid at the common temperature. Even at a much higher heat hydrogen and ſteam exert no mutual action on each other. The effect of hot melted ſulphur on water is dubious, and that of phoſphorus has not been examined: it is ſaid that a mixture of phoſphorus and ſulphur at a boiling heat decompoſes water, phoſphuretted and ſulphuretted hydrogen gas being diſengaged. But of all the combuſtibles charcoal has the moſt marked action on water: if a glaſs or earthenware tube be filled with pieces of charcoal, and then heated red hot, and if ſteam be paſſed into it in this ſituation, both the water and charcoal will by degrees diſappear, and there will be generated a prodigious quantity of mixed gas, conſiſting of carbonic acid, oxyd of carbon, and carburetted hydrogen.

Of the metallic ſubſtances, iron, zinc, tin, and mangaueſe decompoſe water by the aſſiſtance of heat, hydrogen gas being produced, and the metals being reduced to the ſtate of oxyd. Gold, ſilver, platina, and copper have no action on water even at a red heat; the effect of the other metals has not been examined.

The compoſition of water is one of the main pillars on which the theory of Lavoiſier reſts, it will therefore be proper to enter ſomewhat at large into the ſubject.

Water was conſidered by the ancient philoſophers, as a ſimple elementary ſubſtance, undecompoſable, but which by mixture with other bodies conſtituted the principal part of the nutriment of animals and vegetables. The firſt modification of this theory was by Van Helmont, who having raiſed plants ſucceſsfully in pure water, concluded that this fluid alone is convertible into all the vegetable principles. Soon after, Boyle having procured earthy ſcales by long digeſtion of water in glaſs veſſels hermetically ſealed, concluded that this fluid was in part at leaſt convertible into earth: Margraaf obtained the ſame reſult from the repeated ſlow diſtillation of water in glaſs veſſels. But though there was no inaccuracy in the fact, it was demonſtrated by Lavoiſier that the veſſels themſelves during the proceſs loſt a portion of their weight exactly equal to that of the earth produced, and therefore that the earth was in all probability derived not from the water, but from the glaſs; a concluſion which was further confirmed by Dr. Prieſtley, who ſatisfactorily ſhowed that water by long contact with glaſs at a high temperature, always decompoſes a part of it, probably in conſequence of its affinity for the alkali.

While theſe diſcuſſions were going on, the diſcovery of the gaſſeous ſubſtances commenced and ſoon led to an entirely new theory concerning the compoſition of water. The firſt fact of any importance was obſerved by Macquer who found that a bottle filled with hydrogen gas and expoſed to the air burnt with a lambent blue flame unaccompanied by any ſmoke, and that the inſide of the veſſel after the combuſtion was lined with drops of a fluid which appeared to be water. Some time afterwards Dr. Prieſtley exploded in a glaſs veſſel a mixture of oxygen and hydrogen gas, and found that the veſſel became moiſt in the inſide, and was lined with a black matter, ſuppoſed by Dr. P. to originate from the mercury by which the gaſſes were confined.

Induced by the above reſults, Mr. Cavendiſh[b], in 1781, mixed together 500000 grain meaſures of hydrogen gas from zinc and ſulphuric acid, and about 2½ times as much of atmoſpheric air: by combuſtion the bulk of the mixture was diminiſhed to about ⅕ of that of the latter gas, there were obtained 135 grs. of pure water. In order to repeat the experiment in a more unexceptionable manner he exploded a mixture of 19000 grain meaſures of oxygen gas and 37000 of hydrogen gas: 2950 grain meaſures remained unconſumed, and there were obtained 30 grs. of an acidulous fluid, which appeared to be a mixture of water with a little nitric acid. In another experiment the proportion of hydrogen was increaſed, and the reſulting fluid appeared to be pure water, being wholly free from any acid. From theſe he drew the concluſion that the appearance of nitric acid was owing to accidental impurities, and that water was compoſed of oxygen and hydrogen. Soon after Lavoiſier and La Place performed a ſimilar experiment, from which they obtained 295 grs. of pure water, and accordingly concluded that water was compoſed of oxygen and hydrogen. Another well-conducted experiment with the ſame view was executed by Le Fevre de Gineau, of which the following are the principal particulars. 35085.1 cubic inches of oxygen gas obtained from black oxyd of manganeſe, and weighing 254 gros. 10.5 grains, were exploded with 74967.4 cubic inches of hydrogen gas procured from ſoft iron and diluted ſulphuric acid, and weighing 66 gros. 4.3 grains; hence the whole weight of the gaſſes operated on was = 320 gros. 14.8 grains. After the combuſtion there remained 39 gros. 23 grains of elaſtic fluid conſiſting of a mixture of oxygen, azot, and carbonic acid, hence the amount of gas which had diſappeared amounted to 280 gros. 63.8 grains. But there was produced 280 gros. 30 grains of

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[a] Phil. Tranſ. lxxiv. p. 128.

an acidulous liquor, conſiſting of water with a little nitric acid, the loſs of weight in the whole experiment being only 33.9 grains.

The moſt ſatisfactory experiment, however, on this important ſubject, was made in 1790, by Vauquelin, Fourcroy, and Seguin. The oxygen employed by them was procured from oxymuriat of potaſh, and the hydrogen from zinc and diluted ſulphuric acid: of the former the amount was = 13475.198 cubic inches, and of the latter = 25980.563 cubic inches: the combuſtion was carried on very ſlowly; and therefore laſted ſeveral hours, at the expiration of which time there remained 987 cubic inches of gas, conſiſting of the following ingredients, viz.

467	Azot
465	Oxygen
39	Carbonic Acid
16	Hydrogen
987	

The proportions of the gaſſes that had diſappeared were eſtimated at

Hydrogen = 25963.563 cub. inch = 1039.358 grs.
Oxygen = 12570.942 cub. inch = 6209.869 grs.
7249.227

and the quantity of water produced was = 7245 grs. which is as near an approximation to that of the gaſſes conſumed as can poſſibly be expected in experiments of this kind. The water was ſubjected to all the uſual chemical teſts, and appeared to be quite pure; there remains therefore no poſſible objection to the obvious concluſion from this experiment except the appearance of the carbonic acid and azot in the reſidual gas. Of theſe the former may be accounted for by ſuppoſing that a little of the carbon which zinc always contains, was taken up by the hydrogen and underwent combuſtion together with it: the azot was probably an accidental impurity introduced with the oxygen.

The proportion of the ingredients that compoſe water, as deduced from the preceding experiments, are according to

Lavoiſier	15. of Hydrogen to	85. of Oxygen
Le Fevre Gineau .	15.2	84.8
Vauquelin & Fourcroy	14.33	85.66

The only objection that has been urged againſt the above proof of the compoſition of water is the following by Dr. Prieſtley. This philoſopher having concluded, upon as we think inſufficient grounds, that the greateſt part of the ponderable portion of all gaſſes is water, maintained that in the combuſtion of oxygen and hydrogen gas the water that appeared was merely precipitated, and that the real oxygen and hydrogen combined together, forming the reſidual azot or nitric acid according to circumſtances. To this however it may be replied, that the oxygen from manganeſe, and from moſt of the other ſources from which it is procured, may readily be proved by the common eudiometrical proceſſes to be mixed with a ſmall contamination of azot; that Mr. Cavendiſh and others have very ſatisfactorily proved that the proportion of nitric acid or azot obtained depends wholly on the previous impurity of the gaſſes employed; and thirdly, that according to Dr. P's. hypotheſis, real oxygen and hydrogen muſt be both of them entirely imponderable ſubſtances, for in thoſe caſes where no nitric acid appears after the combuſtion of the two gaſſes, but only a ſmall portion of azot, he muſt ſuppoſe not only that this ſmall reſidue of azot contains the whole of the real oxygen and hydrogen, but that as this azot ſtill retains its gaſſeous form it muſt ſtill conſiſt almoſt entirely of water.

The effects of electricity on water ſerve as a further proof of the modern doctrine relative to its compoſition: by paſſing ſhocks along an interrupted golden or platina wire immerſed in water, bubbles of gas are obſerved to be diſengaged at every exploſion, and when a quantity of air has been thus collected, if an electrical ſhock is paſſed into it, an exploſion immediately ſucceeds, water is formed, and the gas diſappears, with the exception of a minute portion which is probably atmoſpheric air previouſly held in ſolution by the water.

The action of certain of the metallic bodies, when heated, on ſteam paſſed over their ſurface, was firſt adduced by Lavoiſier as a proof of the decompoſition of water, and his deductions have been acquieſced in by moſt ſucceeding chemiſts. A quantity of ſoft iron wire being put into a glaſs tube and heated red hot, 100 grs. of water in the form of ſteam were ſlowly paſſed into the tube; the water diſappeared, 416 cubic inches of hydogen gas weighing 15 grs. were produced, and the iron wire was converted into a black brittle oxyd weighing 85 grs. more than at firſt. In this proceſs, ſays Lavoiſier, the water is decompoſed, its oxygen being abſorbed by the iron, and its hydrogen, the other component part, being liberated in the form of gas. Dr. Prieſtley, however, though he admits the fact, explains it in the following manner. The water, according to him, in part unites with the phlogiſton of the metal forming hydrogen gas, while the reſt of the water combines with the calx of the iron. That this black calx really contains water he endeavours to ſhow by the following comparative experiment.[c] A quantity of ſcales of iron and of red oxyd of mercury were moderately heated, in order to render them as dry as poſſible, they were then each put into glaſs receivers of the ſame ſize and form, inverted in dry mercury, and afterwards filled with hydrogen gas from the ſame veſſel. The focus of a burning lens was then thrown upon the metallic oxyds, and it was found that by the time 4 ounce meaſures of the inflammable gas were abſorbed by the iron, the water was running down the ſide of the receiver in drops, whereas although the mercurial oxyd was heated till 8 ounce meaſures of gas were abſorbed, there was hardly any ſenſible quantity of water produced. If this experiment is accurately reported (and there ſeems no reaſonable ground for ſuſpicion) it follows not that the phlogiſtic theory is true, but that the theory of the decompoſition of water can derive no confirmation from it. It is indeed not improbable that there is a real difference between finery cinder or ſcales of iron, and the black ethiops of the ſame metal, the latter being a ſimple oxyd, and the former a hydrat, that is to ſay, a combination of oxyd with water.

Upon the whole, it appears that the only perfectly unequivocal evidence for the compoſition of water is derived from thoſe experiments in which it is actually produced by the combuſtion of determinate proportions of oxygen and hydrogen, and from thoſe in which it is firſt decompoſed and afterwards recompoſed by the agency of the electric fluid. Theſe experiments however have been performed with ſuch particular care by the moſt accurate and intelligent chemiſts of the age, that no fact in the whole circle of chemical ſcience is more ſatisfactorily demonſtrated.

WATERS. Mineral.

Every natural water which flows on the earth, or is found beneath its ſurface, holds ſome foreign matter in ſolution, which, if it does not ſenſibly impart ſome peculiarity in taſte, ſmell, and phyſical properties, may at leaſt be detected by chemical means; and when the quantity or nature of this foreign ingredient is ſuch as to give obvious ſenſible or medicinal properties, it is uſually called a mineral water. The ſalt waters of the ocean and of ſome large inland lakes, are however excluded from this definition, though in every other point of view they are full as intereſting as the ſmaller and comparatively rare ſprings, which have the appellation of *mineral*.

The high importance attached to mineral waters has firſt ariſen from the extenſive celebrity which they have acquired in the cure of diſeaſes; a celebrity which many of them maintain to the preſent moment: and they are equally intereſting to the chemiſt on account of the variety of ſubſtances contained in them, and the mode of their chemical union, and as often illuſtrating the difficult ſcience of geology.

The analyſis of mineral waters has (as might be expected) been benefited by all the improvements which have been progreſſively made in general chemiſtry, and the ſubject has been in particular elucidated by the labours of many excellent chemiſts eſpecially directed to this object. It is ſtill however in many caſes complicated and difficult, and requires conſiderable ſkill and minuteneſs in manipulation, as the ſubſtances operated on are always in ſmall quantity and often numerous.

The ſubſtances hitherto found in natural waters are the following:

1. *Oxygen Gas*, in ſmall quantity, was firſt detected by Scheele. It is contained in almoſt every ſpring water, but never exceeds about $\frac{1}{100}$ of its bulk, and generally is leſs. It exiſts in very looſe combination, and gives no ſenſible properties to the water. It is incompatible with ſulphuretted hydrogen and with ſulphat of iron, and therefore cannot be preſent when theſe are.

2. *Azotic Gas*, in ſmall quantity and in looſe combination exiſts in ſome waters, ſuch as that of Buxton, and at the ſame time a large quantity of it uſually riſes in its gaſeous form along with the water, and paſſes through it in large bubbles. This alſo gives no obvious ſenſible properties.

3. *Common Air* is contained in ſmall quantity in all natural waters, from which the laſt por-

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[c] Doctrine of Phlogiſton, &c. p. 37.

tions are with great difficulty ſeparated. This alſo produces no ſenſible change in water.

4. *Carbonic Acid.* Almoſt all natural waters contain a portion of this gaſeous acid, but which varies extremely from $\frac{1}{100}$ or leſs of the bulk of the water, to an equal bulk. When the quantity is about $\frac{1}{10}$, and uncombined with any other baſe, it gives an agreeable pungency to the taſte, and a ſparkling appearance.

Carbonic acid is found, either totally unaccompanied with any other ſubſtance with which it has any affinity, or totally united with an alkaline, earthy, or metallic baſis; or more commonly partly combined, and partly in exceſs (that is to ſay, more than ſufficient to ſaturate the baſe) and by its exceſs rendering the baſe ſoluble, or, if this exceſs is ſtill greater, imparting to the water the ſame pungency as if it were entirely unaccompanied by any other body. The only carbonats hitherto found in mineral waters are the carbonats of ſoda, magneſia, lime, and iron. Of theſe the two former are ſoluble in water, without any ſuch exceſs of acid as to render the water acidulous, but not the two latter.

5. *Sulphuretted Hydrogen.* A conſiderable number of waters contain a very notable quantity of this gas, which gives its peculiar fetid ſmell, and nauſeous, ſomewhat ſweetiſh taſte. In general the ſulphuretted hydrogen is uncombined with any baſe, but there are ſome waters, particularly ſome of the hot ſprings, which, along with this ſubſtance, contain ſoda, with which it doubtleſs combines, and this compound often contains an exceſs of ſulphur, which it depoſits in a ſmall quantity. Sulphuretted hydrogen is incompatible with no other gas but oxygen.

6. *Sulphureous Acid* is found in ſome ſprings, though rarely, and hitherto has been only met with in the neighbourhood of volcanoes.

7. *Sulphuric Acid* is a very common ingredient in waters, but never uncombined, and it gives a ſenſible acidulouſneſs, only when the ſalt of which it forms a conſtituent part naturally exiſts with exceſs of acid, ſuch as alum and ſulphat of iron. The other combinations of this acid, and in which it is fully neutralized, are ſulphats of ſoda, lime, and magneſia. It has only been found united with potaſh when they both form conſtituents of alum.

8. *Muriatic Acid* has only been found combined and in compleat ſaturation. The muriats of ſoda, magneſia, and lime, are very frequent, the muriats of alumine, iron, manganeſe, and potaſh, are rarely found, and the latter is even doubtful.

9. *Boracic Acid* has been found uncombined in a lake in Tuſcany.

10. *Nitric Acid,* united with potaſh and probably with other baſes, is found in thoſe ſprings that come in contact with the native nitre with which Hungary and ſome other countries abound.

11. *Soda* is the alkali of by far the moſt frequent occurrence in mineral waters. It is ſometimes uncombined or only united to carbonic acid, ſo as to give a ſenſible alkaleſcency to the taſte, and to chemical teſts, and cauſes the water to lather by agitation. Theſe alkaline waters are generally hot.

Soda is alſo found united with ſulphuretted hydrogen, with ſulphuric acid, as Glauber's ſalt, and with muriatic acid, as common ſalt. Both theſe ſalts are very frequent in waters, and the latter often in very large quantity.

12. *Potaſh* has been extracted, as it is ſaid, from one mineral water, and as late reſearches have ſhewn it to be contained in ſome minerals, it may probably be found in other waters.

13. *Ammonia* has been detected by Mr. Cavendiſh in a ſpring near London.

14. *Lime* is never found uncombined in water, but is contained in ſmall quantity in almoſt every natural water, united with ſulphuric acid as ſelenite, and is ſcarcely leſs frequent diſſolved in water by means of carbonic acid. Muriat of lime is alſo not uncommon.

15. *Magneſia* is found in the ſame combinations as lime, but not quite ſo frequently.

16. *Alumine* is not unfrequent in mineral waters. Often it is merely ſuſpended in extremely fine diviſion, but it has alſo been detected in union with the ſulphuric and muriatic acids.

17. *Silex.* This earth was firſt detected by Dr. Black in the water of the celebrated boiling ſprings of Iceland. As theſe waters contain an exceſs of ſoda, and as ſilex is rendered ſoluble in water by means of alkali, it was rationally conjectured that this, together with the great heat to which the water is expoſed, cauſed the ſolution. The ſame earth has however been ſince detected by Dr. Gibbs, in Bath water, which is not alkaline.

18. *Iron* is a frequent ingredient in mineral ſprings, in ſmall quantity, but ſufficient to give a very ſenſible chalybeate taſte and ſmell. It is generally held in ſolution by the carbonic acid, and is then always accompanied by carbonat of lime, and often of magneſia; but ſometimes it is in the form of ſulphat.

All the chalybeate waters depoſit oxyd of iron by expoſure to air, ſo that the track of theſe ſprings on the ſoil is marked by a line of reddiſh yellow ochre.

19. *Copper* is only found as a ſulphat, and in the neighbourhood of copper pyrites, from the decompoſition of which it originates. It is ſtrongly marked by the cupreous taſte.

20. *Manganeſe* diſſolved in the muriatic acid has been found.

21. Beſides theſe ingredients there is often found diſſolved in water a ſmall quantity of a black matter, not cryſtallizable, ſoluble in alcohol, deſtructible by fire, which gives a black tinge to ſulphuric acid, and is obviouſly carbonaceous. Its quantity is always too ſmall for minute examination, but it is uſually conſidered as a kind of *bitumen.* This appears different from the ſoluble part of decayed vegetable matter which water ſometimes meets with and holds in ſolution; and is equally diſtinct from the mucilage which is generated in water when nearly ſtagnant, from the growth of confervæ and other aquatic vegetables.

Some arrangement of mineral waters has been attempted by different writers on the ſubject. This however is of little importance except as relates to their medicinal powers, for even among thoſe kinds that reſemble each other the moſt, ſuch as the carbonated, the chalybeate, the ſulphurous, &c. the individual waters often differ ſo much in chemical analyſis as to require to be admitted as ſeparate genera in any methodical arrangement. The diſtinction of warm and cold ſhould however be noticed, the former being uniformly above the average temperature of the air into which they riſe. Of theſe there are many in the neighbourhood of actual volcanoes, or in countries obviouſly volcanic, which have the temperature of 212° when they burſt into day, and in all probability are much hotter before. Such boiling ſprings are found in Iceland, in Italy, in South America, and in great abundance in Kamſchatka. In this country the Bath water is the hotteſt natural ſpring that we poſſeſs, which riſes to 116°. The cooleſt of our thermal waters is the Matlock, which is ſteadily at 66° in the coldeſt winters.

We proceed to the beſt mode of examining a mineral water, in which ſome differences exiſt among the beſt chemiſts.

The phyſical properties of the water ſhould be firſt noticed.

Theſe are the degree of clearneſs or limpidity—ſparkling or bubbling when poured into a glaſs—the taſte—ſmell—ſpecific gravity—and temperature. It is uſeful alſo to mark the ſtrata of ſoil from which it ſprings, the copiouſneſs of the ſpring, and whether this is affected by a dry or wet ſeaſon, whether any vegetables, fiſhes, or animalculæ are found in it, and whether it incruſts the ſubſtances over which it flows, or depoſits any ſediment.

The next ſtep is the application of *teſts* of different kinds, which is of the utmoſt importance, as by theſe the nature and number of all the foreign ingredients (with one or two exceptions) may be diſcovered, and even ſome opinion may be formed of their relative quantity, and theſe facts are the guide by which the future analyſis is conducted. Several precautions however are required in the application of teſts to avoid deceitful appearances, and the teſts themſelves ſhould be prepared with great care, which may be the more readily done as very minute quantities judiciouſly applied will anſwer every purpoſe. Moſt of the teſts indicate the ſubſtances for the detection of which they are uſed, by producing a ſenſible turbidneſs which gradually collects into a precipitate. There is however with all a limit to this power of precipitation, for when two naturally incompatible ſalts are mixed together in very dilute ſolution, the decompoſition is totally prevented by the great bulk of water compared to the ſaline matters. Thus very ſmall quantities of ſulphat of lime and carbonat of ſoda will coexiſt in the ſame water, and theſe will not be mutually decompoſed till the bulk of liquid is reduced by evaporation. In like manner minute quantities of ſulphat of magneſia and muriated lime, or of muriated lime and ſulphat of ſoda, may be contained in the ſame water.

Another limit to the power of teſts is where the intended decompoſition does indeed take place, but where the quantity of liquid is ſo large that the reſulting compound, inſtead of being precipitated, remains ſuſpended in the water.

The principal teſts are the following:

Litmus. The infuſion or tincture of litmus ſold in the ſhops is a thick liquor of a very dark purple, containing a great body of colour. The purple of litmus is changed to red by every acid, ſo that this is the teſt uſually applied to diſcover any exceſs of acid in mineral waters. It may be uſed either by dipping into the water a paper ſtained with litmus, or by adding a drop of the tincture to the water to be examined, and comparing its hue with that of an equal quantity of the tincture in diſtilled water. In this latter way the change is produced more ſpeedily, and the power of the teſt is ſo great, that the act of blowing through litmus water, diluted ſo as to be barely coloured, will very ſenſibly alter the hue by means of the carbonic acid of the breath which unites with it. It ſhould be remembered that paper or muſlin ſtained with litmus ſpontaneouſly reddens by expoſure to air, alſo that the colour is nearly deſtroyed by long expoſure to light, ſo that when uſed as a teſt they ſhould be recently ſtained. Litmus is alſo reddened by ſulphuretted hydrogen.

As the acid of mineral waters is generally the carbonic, and as this acid, when uncombined with any baſe or in exceſs (in which caſe alone it acts on litmus as an acid) is expelled by boiling for a few minutes, the trial of litmus before and after ebullition will determine whether the acid of the water is fixed or volatile.

Litmus already reddened by an acid will have its purple reſtored by an alkali, and thus it may alſo be uſed as a teſt for alkalies, but it is much leſs active in this reſpect than other direct alkaline teſts.

2. *Red Cabbage* has been found by Mr. Watt[a] to furniſh as delicate a teſt for acids as litmus, and to be ſtill more ſenſible to alkalies. The natural colour of an infuſion of this plant is blue, which is changed to red by acids, and to green by alkalies in very minute quantities. The colour is extracted ſimply by infuſing the freſh leaves of the plant in warm water of about 120° for a few hours. The diſadvantage of this liquor however is that it is peculiarly liable to change by putrefaction, when its properties as a teſt are loſt. To preſerve the cabbage for a length of time Mr. Watt adviſes to mince the leaves, ſpread them on paper, and dry them with a gentle heat, and then put them in cloſely corked bottles. When to be uſed, digeſt ſome of the leaves in a very dilute vitriolic acid which will give a red liquor; bring this to exact neutralization by chalk, ſo that the colour is a pure blue inclining neither to green nor purple, and then pour off the clear liquor and employ it. By adding a little alcohol it will keep good for ſome days.

3. *Brazil Wood.* When chips of this wood are infuſed in warm water they yield a red liquor which readily turns blue by alkalies, either cauſtic or carbonated. It is alſo blued by the carbonated earths held in ſolution by carbonic acid, ſo that it is not an unequivocal teſt of alkalies till the earthy carbonats have been precipitated by boiling. Acids change to yellow the natural red of Brazil wood, and reſtore the red when changed by alkalies.

4. *Violets.* The delicate blue of the common ſcented violet is readily changed to green by alkalies, and this affords a delicate teſt for theſe ſubſtances. Syrup of violets is commonly uſed, as it is generally at hand, being uſed in medicine, but a tincture of the flower will anſwer as well.

5. *Turmeric.* This is a very delicate teſt for alkalies, and on the whole is perhaps the beſt. The natural colour of turmeric either in watery or ſpirituous infuſion is yellow, which is changed to a brick or orange red by alkalies, cauſtic or carbonated, but not by carbonated alkaline earths, on which account it is preferable to Brazil wood. The pure earths, ſuch as lime or barytic water, produce the ſame change, but theſe are never found in mineral waters.

6. *Rhubarb.* Infuſion or tincture of rhubarb undergoes a ſimilar change with turmeric, and is equally delicate.

7. *Sulphuric Acid.* A drop or two of concentrated ſulphuric acid added to water that contains carbonic acid, free or in combination, cauſes the latter to eſcape with a pretty briſk effervеſcence, whereby the preſence of this gaſſeous acid may be detected.

8. *Nitric and Oxymuriatic Acid.* A peculiar uſe attends the employment of theſe acids in the ſulphuretted waters, as the ſulphuretted hydrogen is decompoſed by them; its hydrogen is abſorbed, and the ſulphur ſeparated in its natural form. The theory of this operation has been fully explained under the article *Sulphuret.*

9. *Oxalic acid and Oxalat of Ammonia.* Oxalic acid is the moſt delicate teſt for lime that we are acquainted with, as it decompoſes all the ſoluble calcareous ſalts, and precipitates with the lime as an inſoluble oxalat. This precipitate when collected and dried, and ſtrongly heated, blackens and melts, and the acid burning off, the lime is left white and carbonated. Oxalat of lime, though nearly inſoluble in water, diſſolves without difficulty in a moderate quantity of its own or any other acid, and hence in analyſis oxalat of ammonia is often preferred as no exceſs of this ſalt can rediſſolve the precipitated oxalat of lime. On the other hand the ammonia ſhould not exceed, otherwiſe it might give a falſe indication.

10. *Gallic Acid and Tincture of Galls.* This well known teſt of iron is peculiarly uſeful in the examination of mineral waters, as this is

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[a] Phil. Tranſ Vol. lxxviii.

almoſt the only metal ever met with. Where the iron is in very minute quantity, and the water ſomewhat acidulous, this teſt does not always produce a precipitate but only a ſlight reddening; but its action is much aſſiſted by previouſly adding a few drops of any alkaline ſolution. The pure gallic acid, or the tincture, or the infuſion of galls, act nearly equally well. Sometimes minute quantities of iron are well detected by ſuſpending in the water a piece of the gall-nut for ſome hours.

11. *Pruſſiat of Potaſh and Lime.* The preſence of iron in waters is equally well indicated by theſe pruſſiats, and if the pruſſiat of potaſh is properly prepared, it will only be precipitated by a metallic ſalt, ſo that manganeſe and copper when preſent will alſo be detected, the former giving a white, and the latter a red precipitate.

12. *Lime Water.* This is the common teſt for carbonic acid, as it produces a cloudineſs and precipitate with water that contains any of this acid in whatever ſtate of combination. It is however ambiguous, as it decompoſes all the magneſian ſalts, and the magneſia which is thus ſeparated being abſolutely inſoluble in water falls down as a white precipitate. The aluminous ſalts are decompoſed in the ſame manner. Lime-water alſo produces a cloudineſs with moſt of the ſulphats, owing to the formation of ſelenite.

13. *Ammonia.* This alkali, when perfectly cauſtic, ſerves as a diſtinction between the ſalts of lime and thoſe of magneſia, as it precipitates the earth from the latter claſs but not from the former. There are however two ſources of error in the uſe of this alkali for this purpoſe, one is where carbonic acid is contained in the water, either free or united with magneſia, in which caſe the ammonia becomes partially carbonated, and then alſo decompoſes the ſolutions of lime. The other is where any ſalt of alumine is contained, as ammonia will decompoſe theſe as well as the magneſian ſalts. The former ſource of error may be obviated by adding a few drops of nitric or muriatic acid to the water, and boiling it for a ſhort time, by which the carbonic acid will be got rid of, and the earths will remain in ſolution. Then to diſtinguiſh and ſeparate magneſia from alumine, rediſſolve both in muriatic acid, precipitate the ſolution by carbonated alkali, and then tranſfer the precipitate into cold acetous acid, by which the carbonated magneſia will be directly diſſolved, and the alumine left.

14. *Carbonated Alkalies.* Theſe are ſo far uſeful teſts that they precipitate all the earths from their ſolutions. This is much haſtened by boiling for a few minutes. Where carbonat of potaſh is uſed particular care ſhould be taken of its purity as it generally contains ſilex.

15. *Muriated Alumine.* This teſt is propoſed by Mr. Kirwan as indicative of carbonated magneſia in waters, and which cannot, like carbonated lime, be totally ſeparated by ebullition, but remains till the whole liquid is evaporated. By adding muriated alumine to the boiled water a precipitate of carbonated alumine is found, if carbonated magneſia is preſent, but in no other caſe, unleſs there be an exceſs of alkali, which may eaſily be neutralized.

16. *Barytic Salts.* The nitrat, muriat, and acetite of barytes are all equally good teſts of ſulphuric acid in any combination. The power of this precipitant is greater than that of any other, except perhaps the ſalts of ſilver for muriatic acid. In applying the barytic ſalts the only care required is to neutralize any exceſs of alkali that there may be, with any acid but the ſulphuric; and if the ſulphureous acid be ſuſpected, which is very rare, to free the water from it. The nitrat or acetite of barytes are ſometimes preferable to the muriat, inaſmuch as they introduce into the water to be examined no acid of a kind ſimilar to any already contained. If any exceſs of alkali has cauſed a mixture of carbonat with ſulphat of barytes, they may be readily ſeparated by digeſtion with moderately dilute nitric or muriatic acid, which will diſſolve the carbonat and leave the ſulphat.

17. *Salts of Silver.* The ſalts of ſilver are the moſt delicate teſts for muriatic acid in any combination, producing the precipitated muriat of ſilver or luna cornea, the compoſition of which is conſtant, and has been mentioned under ſilver. Any exceſs of alkali in the water ſhould be previouſly ſaturated by pure nitric acid. The nitrat of ſilver is the ſalt commonly uſed as a teſt, but this as well as the acetite will alſo decompoſe the alkaline and earthy ſoluble ſalts with ſulphuric acid, and a ſulphat of ſilver will be formed, which it is not eaſy to diſtinguiſh by the eye from the muriat. This may be prevented either by previouſly getting rid of all ſulphuric acid in the water by means of nitrat or acetite of barytes, after which all the precipitate of ſilver will be luna cornea; or elſe by employing a ſolution of ſulphat of ſilver, which will then only act on the muriats. It ſhould be obſerved however that nitrat of ſilver is a much more powerful precipitant of the

muriats than of the ſulphats, ſo that if in any water where a barytic ſolution gives but a faint indication of ſulphuric acid, an immediate precipitate is produced by nitrat of ſilver, we may be certain that it is the muriat of ſilver, and not the ſulphat which falls down.

Acetite of ſilver has a particular uſe in decompoſing the fixed alkaline muriats, as we are enabled thereby to diſtinguiſh the alkali more eaſily in the ſupernatant liquor; for by evaporating the latter to dryneſs, rediſſolving the remaining ſalt in alcohol, and gently evaporating the alcoholic ſolution to dryneſs, if it be acetite of potaſh, it will deliqueſce, but if acetite of ſoda it will remain dry and effloreſce.

All the ſalts of ſilver alſo give a black or dark brown precipitate with the ſulphuretted waters, which is as delicate a teſt of ſulphuretted hydrogen as any that we poſſeſs.

18. *Salts of Lead.* The nitrat and acetite of lead are the ſalts of this metal employed as teſts. They will indicate the ſulphuric, muriatic, and boracic acids, and ſulphuretted hydrogen or ſulphuretted alkali. The water being firſt freed from any exceſs of alkali by ſaturation with nitric acid, the addition of either of theſe ſalts of lead will decompoſe, and form a white precipitate with the acid of all the contained ſulphats or muriats. But as ſulphat of lead cannot by the eye be diſtinguiſhed from the muriat, the precipitate ſhould be digeſted in acetous or very dilute nitric acid or merely boiled in a good deal of diſtilled water, by any of which means the muriat will be diſſolved, but the ſulphat will be untouched. In theſe precipitates the acetite of lead is a more ſenſible teſt than the nitrat, but as the former when long kept will be partly decompoſed by pure water, it ſhould be aſſayed with water, and a little more acetous acid added if neceſſary.

Acetited lead is alſo decompoſed by the carbonated earths and iron, ſo that the water ſhould be boiled before this teſt is applied. This ſalt alſo produces an inſoluble borat of lead when boracic acid is preſent in the water, which takes place in one or two rare inſtances. The borat of lead is diſtinguiſhed from the ſulphat of this metal by being ſoluble in nitric acid of 1.3. ſp. gr. and from the muriat by being inſoluble in water, or in weaker acids. But where boracic acid is ſuſpected, Mr. Kirwan adviſes firſt to ſeparate the ſulphuric acid (if any) by acetited ſtrontian, and the muriatic acid by acetited ſilver, neither of theſe acetites being decompoſed by pure boracic acid.

Acetite of lead is alſo a very delicate teſt for the ſulphurets, which it ſhews by turning to a deep brown or black. It is often applied by tracing characters on paper with acetite of lead, and immerſing it in the ſulphuretted water.

19. *Soap.* A ſolution of ſoap in diſtilled water, or in alcohol, is curdled by water containing any earthy ſalt. It is therefore a teſt of ſome uſe but not diſcriminative. The metallic ſalts produce the ſame effect, but the curd is then coloured.

20. *Tartareous Acid.* This acid is of uſe in diſtinguiſhing the ſalts with potaſh (with which it forms a precipitate of cream of tartar) from thoſe of ſoda which it does not precipitate. It is neceſſary however that the ſolution of ſalt with the baſis of potaſh (the ſulphat or muriat for example) be much ſtronger than occurs in any mineral water in its natural ſtate, ſo that it muſt be concentrated by evaporation.

21. *Nitro-Muriat of Platina.* This ſalt is ſtill more diſcriminative between potaſh and the other alkalies than acid of tartar, and will produce a precipitate with a very weak ſolution of any ſalt with potaſh. It has not yet been much employed, but may often be of uſe.

22. *Alcohol.* This moſt uſeful reagent is applicable in a variety of ways in the analyſis of mineral waters. As it diſſolves ſome of the ſubſtances found in mineral waters, and leaves others untouched, it is a means of ſeparating them into two claſſes, which ſaves conſiderable trouble in the further inveſtigation. Thoſe ſalts which it does not diſſolve, it precipitates from their watery ſolution, but more or leſs completely according to the ſalt contained, and the ſtrength of the alcohol, and, as a precipitant, it alſo aſſiſts in many decompoſitions. The great utility of *alcohol* to the analytical chemiſt has been already deſcribed under that article, and will be further mentioned in this.

The above are the principal teſts or reagents employed. Several others might be enumerated which will eaſily ſuggeſt themſelves to the practical chemiſt, and the theory of theſe reſpective operations will be better underſtood by conſulting the articles themſelves, to which we ſhall refer the reader to avoid repetition.

Before we deſcribe the mode of analyſis we may ſhortly recapitulate thoſe foreign ſubſtances contained in mineral waters, for which there exiſts any appropriate *teſt* or chemical reagent by which its nature may be readily detected, and which therefore is to direct the operator in his further analyſis. Where the precaution to be uſed in applying them has been mentioned, we ſhall not repeat it.

Oxygen Gas—Atmoſpheric Air. The preſence of oxygen in water may be detected, according to Scheele, by filling a phial brimfull with it, dropping in a piece of newly cryſtallized ſulphat of iron, and corking the bottle cloſe. In a little time the ſalt will be diſſolved, and in a few hours an ochery precipitate will be perceived, owing to the abſorption of oxygen by the oxyd of iron of the ſalt, which then becomes inſoluble.

Carbonic Acid.

(Teſt). Lime or ſtrontian water—Litmus when in exceſs—Sulphuric acid—boiling.

Sulphuretted Hydrogen.

(Teſt). Nitric and oxymuriatic acids—Salts of lead and ſilver. A few globules of clean mercury allowed to remain for ſeveral hours in contact with the water, cloſely corked, will detect very minute quantities of it by being blackened at the ſurface. Silver leaf will anſwer as well.

Sulphureous Acid.

(Teſt). Mr. Kirwan gives as the only deciſive teſt of this acid gas being held in ſolution in water, that when mixed with a tincture of roſes reddened by an acid it renders this tincture colourleſs. This acid is alſo known by the ſmell. If perfectly pure it ought not to precipitate muriated barytes nor nitrated mercury, but it always does, which perhaps is owing to an inſeparable admixture of ſulphuric acid.

Mineral Acids uncombined.

(Teſt). Reddening litmus after the water has been boiled.

Boracic Acid.

(Teſt). Acetite of lead.

Carbonated Alkalies.

(Teſt). Turmeric—Rhubarb—Violets. If the change of colour does not take place after ebullition for ſeveral minutes, it ſhews that the alkali was ammonia.

Ammonia.

(Teſt). The preſence of this alkali is partly diſtinguiſhed in the way mentioned above, but more certainly by boiling a pretty large quantity of the water in a retort, carefully collecting the firſt ounce or two that diſtills, and moiſtening with this portion a piece of well-burnt lime, by which the ammoniacal ſmell will be diſtinctly perceived. The object of this diſtillation is to concentrate in a ſmall compaſs all the ammonia of a larger quantity of liquid, which might be too dilute to indicate this alkali without this method.

Carbonats of Lime and Magneſia.

(Teſts). Precipitated by ebullition, the former totally, the latter partially. After boiling, the magneſian carbonat remaining is indicated by muriat of alumine.

The Acid of the Sulphats.

(Teſts). Salts of barytes and lead.—All the ſulphats are alſo inſoluble in alcohol, and precipitable by it from their watery ſolutions.

But ſulphat of lime exceeds all the others in the eaſe with which it is thus precipitated.

The Acid of the Muriats.

(Teſt). Salts of Silver.—Alcohol unleſs very highly rectified diſſolves a ſmall quantity of muriat of ſoda, and does not precipitate the muriats with the eaſe with which it ſeparates the ſulphats.

Neutral Salts of Potaſh as diſtinguiſhed from thoſe of Soda.

(Teſts). Tartareous acid—Nitro-muriat of Platina—Acetited barytes with the ſulphats; and acetited ſilver with the muriats.

The Earth of the Calcareous Salts.

(Teſt). Oxalic acid or oxalat of ammonia.—Pure ammonia *not* precipitating it. Sulphuric acid, or better the alkaline ſulphats, alſo decompoſes the muriat of lime, and the reſulting ſelenite is precipitated. This may be haſtened by alcohol.

The earth of the Magneſian Salts.

(Teſts). Pure ammonia—Lime-water.

The Earth of the Aluminous Salts.

(Teſt). Pure ammonia—Lime-water.

Silex.

(Teſt). This is chiefly ſuſpected by its refuſing to diſſolve in any acid after the water has been once evaporated to dryneſs. It may be more certainly aſcertained by melting it before the blow-pipe with three or four parts of dry carbonat of ſoda into a clear globule, which *then* will diſſolve in water. Some of the waters that contain ſilex will *gelatinize* when evaporated almoſt to dryneſs, after which the ſilex will not rediſſolve by reſtoring the water which has been loſt. This agrees with the known properties of ſilex in the analyſis of minerals.

Salts of Iron.

(Teſts). Galls—Pruſſiat of potaſh or lime. The carbonat of iron is precipitated totally by boiling.

Salts of Copper.

(Teſts). Pruſſiat of potaſh—Ammonia—Metallic iron.

Manganeſe.

(Teſt). The brown colour of its oxyd, and its ſolubility in carbonat of potaſh.

Carbonaceous Matter.

(Teſt). Diſſolves in concentrated ſulphuric acid, giving it a clear brown colour.

Proceſs of Analyſis.

The firſt ſtep in the examination of a mineral water, after the ſpecific gravity, taſte, ſmell, and phyſical properties have been noted, is to endeavour to form as accurate a notion as poſſible of the nature of its contents by the application of the ſeveral teſts which have juſt been deſcribed. It is never neceſſary to apply all that have been enumerated, as many of the ſubſtances which they indicate are incompatible with others.

When this done the proceſs of analyſis may be begun, but it may be remarked that the mode muſt vary conſiderably according to the indication given by the teſts, nor is it eaſy to give in a moderate compaſs the management to be purſued in every poſſible caſe. In fact a perſon ſhould already be a ſkilful chemiſt, familiar with the practice of chemical operations, with the reſpective affinities of ſubſtances, and with their diſtinctive characters, and habitudes, before he undertakes any analyſis.

For the deſcription of theſe proceſſes we muſt refer our readers to the reſpective articles, as it would be an uſeleſs repetition to give in this place any more than a general outline of them.

To determine the gaſeous contents.

When any gaſſes are indicated by the proper teſts, it is uſual to begin by determining their nature and quantity.

If carbonic acid without any ſulphuretted hydrogen be preſent, fill a narrow necked retort with the water taken at the ſpring head (having previouſly found the capacity of the neck of the veſſel, which muſt of courſe be left empty) dip the beak under a graduated jar filled with mercury, and bring the water to ebullition. At this temperature all the carbonic acid (or nearly ſo) is diſengaged, and collects in the mercury jar. When no more air-bubbles are given out (which muſt be diſtinguiſhed from the mere motion of ebullition) remove the retort. The air ſtanding above the mercury will then conſiſt of the carbonic acid, together with any oxygen or azot that may be contained in the water, and all the atmoſpheric air that was contained in the neck of the retort, which laſt has been diſplaced and expelled by the hot aqueous vapour in its paſſage through. Theſe may be ſeparated either by lime-water, or by cauſtic or ſemicauſtic alkali, ſuch as common pearlaſh, which abſorb the carbonic acid only, and conſequently indicate its quantity in the portion of water that was employed.

After this, the reſidue may be examined to find the relative quantities of oxygen and azot in the methods already deſcribed under the article *Eudiometer*, and if more of either appears than will be accounted for by the air in the neck of the retort, this exceſs will belong to the water under examination. The corrections and precautions requiſite in the eſtimation of the bulk and weight of airs, relative to temperature and preſſure, ſhould be carefully remembered, and will be found under the article *Gas.*

In expelling air from water by ebullition as little ſpace as poſſible ſhould remain in the neck and conducting tube of the apparatus, on which account a glaſs globe, with a ſhort and moderately wide neck, and a bent tube fitted thereto is preferable to a retort, for the neck of the latter is purpoſely made wide and roomy, this being an advantage in common diſtillation. A little water muſt of courſe diſtill over during the boiling, which will riſe through the mercury along with the gas, but this will not materially interfere with the accuracy of the experiment.

As a mercurial pneumatic apparatus is not always at hand, the gas may be received through water, and the abſorption of the gas by this fluid may be in a great degree prevented by employing it very hot, for at a high temperature water will hardly abſorb fixed air. This however is not quite ſo accurate as with the mercurial apparatus.

Some chemiſts have endeavoured to eſtimate the quantity of carbonic acid without any ebullition and expulſion of the gas, ſimply by adding lime-water to the mineral-water freſh from the ſpring, and collecting, drying and weighing the carbonat of lime thus produced. But this method is extremely fallacious in moſt caſes, for the lime-water will alſo precipitate all the carbonat of lime held in ſolution by the carbonic acid, and the carbonat of magneſia, and beſides will decompoſe the other magneſian ſalts, and cauſe their earth to precipitate. So that this method is inadmiſſible in by far the greater number of actual caſes, and can only apply where the water contains no other ingredients than carbonic acid, and ſalts with the baſes of lime or alkali.

Where the water contains ſulphurous acid gas with or without carbonic acid, Mr. Kirwan recommends to expel both by ebullition in the uſual way, receiving them over mercury; to add ſolution of pearl-aſh to abſorb both, then gently to evaporate the alkaline ſolution nearly to dryneſs, and to expoſe it for ſome days to the air, by which the ſulphite of potaſh obtained by union of the ſulphurous acid with the alkali will be converted into ſulphat. This being obtained ſeparate, the quantity of ſulphurous acid may be found, eſtimating that 100 grains of ſulphat of potaſh contain 45 of ſulphuric acid, equal to 15 of ſulphur, equal to 30 grs. or 42.72 cubic inches of ſulphurous acid gas.

Inſtead of obtaining the ſulphat of potaſh ſeparate, which it is difficult to do exactly, the alkaline ſolution, after the ſulphite has become ſulphat, may be ſaturated with muriatic acid, and the quantity of ſulphuric acid then eſtimated by muriat of barytes.

The accurate eſtimation of ſulphuretted hydrogen is very difficult, particularly when mixed with carbonic acid gas. The ſulphuretted hydrogen may indeed be expelled almoſt entirely by boiling, but when received over mercury it is partly decompoſed by this metal, and when by water it is partly abſorbed by it, though this laſt inconvenience is in a good meaſure prevented by warming the water.

There are two ways of eſtimating it. One of them is the following: boil the water and receive the gaſſes over mercury in the uſual way. Theſe may conſiſt of carbonic acid, ſulphuretted hydrogen and azot, but not oxygen, this being incompatible with ſulphuretted hydrogen. It is neceſſary in order to obtain the carbonic acid pure that the ſulphuretted hydrogen be firſt ſeparated, for the alkalies and the alkaline earths abſorb both. For this, Mr. Kirwan adviſes, firſt to diſplace any mercury remaining in the jar by dipping it a little way in hot water, whereby the mercury will fall down and the water take its place. Then dip the jar into a ſmall veſſel full of moderately ſtrong nitrous acid, by which the acid will mix with the water and come in contact with the gaſſes, and abſorb very ſpeedily or decompoſe the ſulphuret, and leave the carbonic acid and azot, which laſt may afterwards be ſeparated by an alkali.

But as all the ſulphuretted hydrogen cannot be expelled undecompoſed from the water, the above method is quite accurate only for the other gaſſes. Mr. Henry ſuggeſts as an improvement to the above method, inſtead of uſing nitrous acid, to throw up oxymuriatic acid gas to the mixed gaſſes ſtanding over water, till the jar is filled, cloſing the jar with a ground ſtopper, and allowing the mixture to remain for twenty-four hours. Then on opening the jar under water, a quantity of this fluid will ruſh in to fill the vacuum produced by the decompoſition of the ſulphuretted hydrogen, and ſtanding about half an hour without agitation, the exceſs of oxymuriatic acid will be abſorbed, and only the carbonic acid and azot will remain. In this proceſs the oxymuriatic acid gas ſhould be quite pure, ſuch as is obtained from oxymuriat of potaſh and muriatic acid, and equal in bulk to the other gas, but the required purity of this gas is certainly an objection.

The mere quantity of ſulphuretted hydrogen contained in any water is perhaps beſt aſcertained by decompoſing this gas altogether when in ſolution in the water, without attempting to expel it by ebullition. The ſubſtances employed for this may be either nitrous or oxymuriatic acid, which if properly managed precipitate the ſulphur of the gas totally in its proper form. The theory of this decompoſition has been explained under the article *Sulphuretted Hydrogen*. There are however two cauſes of error to be avoided, one is, that the proportion of gas contained in natural water is ſo ſmall that a moderate quantity of nitric acid ſoon becomes too dilute to produce its complete effect. The other difficulty (which particularly applies to the oxymuriatic acid) is, that if an exceſs of it be uſed, the precipitated ſulphur again diſappears, being converted into ſulphuric acid. This laſt circumſtance indeed might be taken advantage of in the analyſis, by converting the whole of the ſulphur to ſulphuric acid, but it ſeldom happens that any natural water is free from ſome ſulphat or other, and the acid of theſe could not eaſily be extracted previouſly to the acidification of the ſulphur, and of courſe would be confounded with it. The moſt practicable method would be firſt to acidify the ſulphur of the freſh water and precipitate the whole by a barytic ſolution; and then to collect the precipitate from an equal quantity of the water *boiled* and decompoſed by the barytic ſolution, and the difference in the weights of the two precipitates of ſulphat of barytes would indicate the quantity of ſulphuric acid belonging ſimply to the ſulphuretted hydrogen.

Mr. Kirwan[b] gives the following method of decompoſing the ſulphuretted hydrogen contained in any water and collecting the ſulphur. Introduce two pounds of the hepatic water into a bottle, ſo as to fill about $\frac{3}{4}$ of its capacity, and place it in a tub filled with common water. Into this bottle introduce a few cubic inches of nitrous air, which will be immediately decompoſed, and after ſome time the water will become turbid. Continue letting up nitrous air as long as the redneſs of its mixture with common air ſhews its decompoſition; this done, turn up the mouth of the bottle and blow out the reſiduary air. If the hepatic ſmell continues in the water, repeat the addition of nitrous air as above till the ſmell is deſtroyed. Then add a few drops of nitrous acid to prevent the precipitation of the earths, heat the water to 150° for an hour and filter it. The exceſs of weight which the dried filter will gain over its original weight will indicate the weight of ſulphur ſet free by this proceſs, from which the quantity of ſulphuretted hydrogen may be eſtimated, allowing 3.33 cubic inches of the gas for every grain of ſulphur.

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[b] Eſſay on Mineral Waters, p. 194.

But under the article *ſulphuretted hydrogen* we have ſhewn the great diverſity in the eſtimation of its compoſition by two very able chemiſts; a diverſity which perhaps may ariſe from ſome error in the mode of computation, or with equal probability may depend on a real variation in the proportion of the conſtituents of this gas according to the mode in which it is procured or other circumſtances. Hence we can have but little reaſon to truſt implicitly in the mode of eſtimating quantities of ſulphuretted hydrogen by the actual weight of ſulphur produced, eſpecially in ſuch dilute ſolutions of this gas as the native ſulphureous waters are, of which ſome of the ſtrongeſt, ſuch as that of Harrogate, contain no more than about $\frac{1}{12}$ of their bulk.

Eſtimation of the Earthy and Metallic Carbonats. Theſe when they occur ſhould next be examined. They are, carbonat of magneſia, of lime, of iron, and ſometimes of alumine. Of theſe the three latter are totally precipitable by ebullition for a quarter of an hour, but the former only partially, and is not totally ſeparated till the water is evaporated to a very ſmall bulk. A given quantity therefore of the water (which may be the portion from which the gaſſes have been ſeparated by ebullition) ſhould firſt be boiled for a quarter of an hour, and after ſtanding for a time the earthy ſediment may be collected, edulcorated and dried. Then add dilute cold muriatic acid, which can rediſſolve only lime, magneſia, and oxyd of iron, and leave the alumine. Add cauſtic ammonia by drops to the ſolution, which will ſeparate firſt the oxyd of iron coloured, and then the magneſia nearly white, whilſt the lime will remain. If no magneſia is detected, nothing further is neceſſary than to aſcertain the actual quantities of the carbonats of lime, iron and alumine, the latter being left undiſſolved by the muriatic acid, and, of the two former, the iron alone being precipitated by ammonia; and thus each ſubſtance is obtained ſeparate, and may be brought to their original ſtate of carbonat by ſubſequent proceſſes which will eaſily ſuggeſt themſelves. But if the ſediment depoſited by boiling the water contains any carbonat of magneſia, it is a proof that ſome of the ſame earthy ſalt remains in ſolution, which may alſo be further confirmed by the boiled water giving a precipitate with muriated alumine. In this caſe a conſiderable quantity of the water ſhould be boiled down uninterruptedly to the bulk of a few ounces and allowed to cool. Then collect the entire ſediment, edulcorate it and dry it. It now contains all the earthy and metallic carbonats, but is perhaps mixed with ſome ſelenite, which is depoſited towards the end of the evaporation. Cold dilute muriatic acid will then rediſſolve the carbonats of lime, magneſia, and iron, and leave the ſelenite as well as the alumine. The muriatic ſolution then contains all and only the lime, magneſia, and oxyd of iron which exiſted in the water in the ſtate of carbonat, theſe Mr. Kirwan propoſes to ſeparate in the following way. Add ammonia to the ſolution to ſeparate the magneſia and iron and leave the lime. Rediſſolve the magneſia and iron in muriatic acid, and precipitate both by carbonat of ſoda, and expoſe the precipitate while moiſt to the air for a few days. Diſtilled vinegar applied without heat will then rediſſolve only the carbonat of magneſia and leave the iron. The reaſon of this ſecond ſolution of the magneſia and iron is in order to carbonate the magneſia by precipitation with a carbonated alkali, for when this earth is pure it is not eaſily ſoluble in acids, and it is by the eaſy ſolubility of its carbonat that it is to be ſeparated from the oxyd of iron in this inſtance.

The above method of ſeparating the earths and iron is inaccurate, inaſmuch as it is fully aſcertained that ammonia will never ſeparate the whole of the magneſia from its acid ſolutions, and therefore though it is extremely uſeful as a teſt to aſſay any liquor for magneſia, it cannot be depended on to give the actual quantity of this earth. The difficulties and the beſt methods at preſent known of ſeparating lime and magneſia, are mentioned under the articles *Sulphat* (p. 389), *Muriat* (p. 133), and *Lime*, (p. 41). They are, either by converting both into ſulphats and calcining the mixture, which will render the ſulphat of magneſia alone ſoluble in cold water; or by converting them into muriats and heating them nearly to redneſs, by which the muriatic acid is driven off from the magneſia alone (whereby it is rendered inſoluble in water) and not from the lime. In either caſe however the preſence of iron would prove embarraſſing, and in the latter much of it would be volatilized with the muriatic acid, and therefore we ſhould adviſe, firſt to ſeparate it from the muriatic ſolution by pruſſic acid or ſuccinat of ammonia, then to throw down the earths by carbonat of ſoda, to edulcorate, and rediſſolve them either in ſulphuric or muriatic acid, according to the method of ſeparation adopted. On the whole we ſhould prefer the ſulphuric acid.

Eſtimation of the remaining Subſtances.

We have now ſeparated from the water, and eſtimated all the gaſſes and all the earths and oxyd of iron held in ſolution by carbonic acid. The water therefore now can only contain fixed ſalts, with alkaline, earthy, or metallic baſes, ſilex, and extractive or carbonaceous matter. If the preſence of carbonat of magneſia has made it neceſſary to evaporate nearly to dryneſs, and if any ſulphat of lime has precipitated, it ſhould be added to the remaining water after the magneſian carbonat has been abſtracted.

It ſhould be premiſed that if the teſts indicated any ammonia in the water, it ſhould firſt be ſeparated by diſtillation in the way already mentioned.

The further operations to be performed upon the water muſt be regulated in a good meaſure by the contents pointed out by the different reagents. If, for example, no earthy ſalt now remains, but both ſulphuric and muriatic acid are indicated, and at the ſame time no exceſs of acid or alkali exiſts, we may conclude that all the remaining ſaline ingredients are ſulphat and muriat of ſoda (potaſh being extremely rare) and it then becomes a queſtion which is the beſt mode of eſtimating their reſpective quantities. If at the ſame time an exceſs of alkali exiſts, we may conclude that together with theſe ſalts carbonat of ſoda is contained.

The way of aſcertaining the fixed ſalts of any mineral water, which till lately has been the moſt frequent, is that recommended by Bergman, and which indeed would firſt ſuggeſt itſelf, namely, to evaporate the liquor till the leaſt ſoluble ſalt began to cryſtallize, and then by a judicious alternation of gradual warmth, and of cooling, to endeavour to obtain the diſtinct cryſtals of each ſalt to the laſt drop of the ſolution.

But though evaporation and cryſtallization are extremely uſeful and indeed almoſt indiſpenſible to ſatisfy the chemiſt as to the real nature of the ſaline and other contents, it has long been found impracticable even by the moſt ſkilful operators, perfectly to ſeparate any two ſalts in this manner. This is cauſed partly by the increaſed ſolubility which two ſalts give to each other when held in ſolution in the ſame liquid; partly by the change in the natural form of cryſtals which is ſometimes produced; and partly by the extreme difficulty of picking out cryſtals which grow more and more minute in proportion as the bulk of the ſolution is leſſened by the repeated abſtraction of its contents. The great difficulty too in retaining exactly the ſame proportion of water of cryſtallization is another objection to this mode, though this might be remedied by expoſing the ſalt, when obtained, to ſuch a degree of heat as will produce an uniform deſiccation. The beſt analyſts therefore have nearly abandoned the attempt at eſtimating actual quantities of ſaline ingredients (where accuracy is required) by cryſtallization, except where no other mode can well be adopted, as is the caſe with the nitrous ſalts. The method commonly preferred is to decompoſe theſe ſalts in ſuch a manner as to produce an inſoluble precipitate with one or other of their ingredients, and from the weight of this to eſtimate (from previouſly known data) the quantity of the decompoſed ſalt. The ſalts with alkaline baſes are eſtimated by the precipitate which their acids form with earthy or metallic baſes; the ſulphats, for example, are analyſed by ſalts of barytes or lead; the muriats, by ſalts of ſilver; the borats, by lead, &c. The ſalts with earthy baſes are eſtimated by ſeparating either their earth (generally by a carbonated alkali) or their acid, and where it can be done it is more ſatisfactory to employ both.

Another proceſs is uſed to aſcertain quantities of unneutralized acid or alkali exiſting in any water, as of ſoda for example, or rather its carbonat, which is a frequent ingredient in many hot mineral waters. This was firſt uſed we believe, by Dr. Black, in his analyſis of the Iceland hot waters,[c] and it conſiſts in exactly ſaturating the alkali with a portion of any acid (or *vice verſa*, the acid with an alkali) whoſe ſtrength has previouſly been determined by trials upon known quantities of the ſame acid or alkali. Thus in the above example a very dilute vitriolic acid was uſed, whoſe power of ſaturating ſoda had been previouſly tried, and the delicate teſts of litmus and violet were employed to hit the preciſe point of ſaturation.

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[c] Edinb. Tranſact. Vol. iii.

We ſhall add in the appendix a table of a few of the moſt important correſponding quantities of precipitates with ſalts which are the moſt frequently uſed in analyſis.

To proceed with the examination of the deaerated water freed from the earthy carbonats.

Evaporate a given quantity (which with moſt waters ſhould not be leſs than about a gallon) with a heat which, to ſave time, may be that of boiling till towards the end, when a more gentle heat muſt be uſed to avoid decompoſing or volatilizing any part of the ingredients. The evaporation may be carried on in almoſt any clean veſſel, eſpecially where no exceſs of acid exiſts in the water, but when only a few ounces are left, it ſhould be transferred to a glaſs or ſilver diſh, with every thing that may have ſubſided in the boiling, and brought by a ſlow fire to perfect dryneſs. The further management of this reſidue depends on the nature of its contents. If previous experiments have ſhewn that no earthy or metallic ſalt exiſts in the boiled water, it will be ſufficient to re-diſſolve it in a little warm diſtilled water, by which any ſilex that may be contained will be left behind; and the latter may be ſtill further known by its inſolubility in muriatic acid, and by fuſion with ſoda.

The aqueous ſolution can then contain only any acid or alkali which may exiſt in exceſs, and any neutral ſalts with alkaline baſes. Then ſaturate an aliquot part of the ſolution and aſſay it with tartareous acid, which in this concentrated ſtate, will precipitate cream of tartar if potaſh exiſts. If none is found (which is by far the moſt common) the alkali muſt then be ſoda, and the nature of the acids being alſo found, the reſpective quantities of the neutral ſalts may eaſily be inferred in the way above mentioned. Thus if the water indicate ſulphuric and muriatic acid, and an exceſs of ſoda (which is the caſe with the Carlsbad water, analyſed by Klaproth) the alkali is firſt to be ſaturated with ſulphuric acid of a known ſtrength, and the whole ſulphat decompoſed by acetite of barytes. Then, calculate the equivalent quantity of ſulphat of ſoda to the ſulphat of barytes obtained, ſubtract that portion of it which is formed by the ſulphuric acid employed to ſaturate the uncombined ſoda, the reſidue is the portion of ſulphat of ſoda natural to the water. The muriat of ſoda is then indicated by nitrat of ſilver, allowing 100 parts of luna cornea to be equivalent to 428.25 parts of common ſalt.

The exceſs of fixed acid where it exiſts is almoſt always the ſulphuric, but it has hitherto been only found in company with alum, or other ſulphuric ſalts, that have a natural exceſs of acid. If it ſhould ever be found only aſſociated with alkaline ſulphats or muriats, this exceſs may be found by adding barytic water merely to ſaturation, and no further, which will then only indicate the exceſs of acid.

But the greater number of mineral waters contain ſome earthy ſalt, the acid of which is fixed, ſo that it remains in ſolution after boiling and concentration. This acid is hardly ever any other than the ſulphuric and muriatic, and the earth is moſt commonly lime or magneſia. Therefore only four earthy ſalts may be expected (not all together indeed, as they would decompoſe each other) namely, ſulphat of lime, muriat of lime, ſulphat of magneſia, and muriat of magneſia. Of theſe ſalts the ſulphats are inſoluble in alcohol, but the muriats are extremely ſoluble. This therefore affords a very uſeful means of ſeparating ſome of them. For this purpoſe put the entire dry reſidue in a phial, pour on it about five or ſix parts of highly rectified alcohol, and let the mixture remain for ſome hours with frequent agitation. The alcoholic ſolution can then contain only muriat of lime and magneſia, if the alcohol has been highly rectified; if not it may alſo diſſolve a little muriat of ſoda. The method of ſeparating and eſtimating a mixed muriat of lime and magneſia, has already been mentioned. The reſidue which is not diſſolved by the alcohol may contain the ſulphats of lime and magneſia, of which the latter ſalt is eaſily ſoluble in water, but the former with great difficulty unleſs aſſiſted by an acid. The mode of ſeparating theſe has alſo been mentioned.

With regard to ſulphat of lime which is ſo common an ingredient in waters, it is of uſe to know that when it is in ſolution in as ſmall a bulk of water as poſſible, and eſpecially when aſſiſted by an exceſs of acid, it may be totally precipitated by adding a much ſmaller quantity of alcohol than will ſeparate any other of the ſulphats, as has been mentioned under the article *Sulphat of Lime*.

Sulphat of iron is now and then found in mineral waters, though much more rarely than might be expected from the frequency of pyrites in moſt parts of the earth. When a water remains chalybeate after boiling, we may pretty ſafely infer that the iron is united to the ſulphuric acid But as ſulphat of iron is partly decompoſed by expoſure to air, the reſidue, after the water has been evaporated to dryneſs, contains both ſulphat of iron and ſome uncombined oxyd of this metal, and the ſulphat is then partly changed to the red ſulphat, or that in which the iron is in its higher ſtate of oxygenation. It is not poſſible therefore to procure with any accuracy ſmall quantities of ſulphat of iron from any mineral water by evaporation, or any other known way, ſo that the only method ſeems to be, to obtain the whole of the oxyd of iron ſeparate from every other ingredient, to bring it to a known ſtate of oxygenation, and then to eſtimate its equivalent quantity of green or cryſtallized ſulphat.

The methods in which this may be done will be ſuggeſted by comparing the beſt analyſes of iron. Pruſſiat of potaſh ſeems on the whole to be preferable where this ſalt is properly prepared. Muriat of iron has not yet been found. If uncombined with the ſulphat, it might be diſcovered by not depoſiting its oxyd during evaporation, and by being ſoluble in alcohol; and even if both ſalts of iron were preſent, and no earthy muriat, it might be detected by evaporation, by treatment with alcohol, which would then diſſolve both ſalts of iron (the green ſulphat being converted by the boiling into the red, which is ſoluble in alcohol) and by ſulphat of ſilver added to the alcoholic ſolution. But where other muriats ſoluble in alcohol alſo exiſted, it would require a complicated proceſs to detect muriat of iron combined with the ſulphat.

In giving the reſults of the analyſis of a mineral water, the preſent ſtate of chemical knowledge demands that the particulars of the proceſs (at leaſt the outlines) ſhould be given, together with the data from which the inferences of quantities are eſtimated. It is alſo eſſential for the operator to preſerve ſome uniform method of drying his ſalts and precipitates, and the temperatures at which this is performed ſhould never be omitted. A greater attention to this point would enable us often to reconcile the ſtatements of chemiſts of known fidelity, which now differ widely, and might lead to many important diſcoveries in the complicated and difficult ſubject of chemical affinity.

WATER OF THE SEA.

The analyſis of ſea-water and the chemical uſes to which it is applied, will be found under the articles MURIAT, p. 124, and SULPHAT, p. 388, of this volume.

WATER OF CRYSTALLIZATION is that portion of water which moſt ſalts retain when in their cryſtallized form. The relative quantity of this water to the ſaline part varies extremely. In ſome it is not more than 2 or 3 per cent. in others it forms more than half the cryſtal. In the former caſe the ſalts are hard and decrepitate when briſkly heated; in the latter they liqueſy. The quantity of this water often varies in the ſame ſalt much more than would be expected from the ſimilarity in form and appearance, which will partly account for the great difference which we find in the eſtimation of their contents, as given by different chemical writers.

WAX. *La Cire.* Fr. *Wachs.* Germ.

There are two or three ſubſtances which reſemble each other ſo cloſely as to have received the name of Wax. The firſt, and by far the moſt important is *Bees Wax*, which is conſumed in ſuch vaſt quantities for giving light, and is alſo uſed for a variety of other purpoſes. Another kind of wax is the myrtle wax, which is extracted pretty largely in Louiſiana and ſome other parts of America, from the *Myrica Cerifera.* Another ſubſtance very ſimilar to wax is the *Pe La* of the Chineſe, the product of an inſect, the exact ſpecies of which is not known; and the white matter which yields the LACCIC *Acid* has alſo a ſtrong reſemblance to wax.

The properties which all theſe ſubſtances have in common are, fuſibility at a moderate heat; when kindled, burning with much flame; inſolubility in water, ſolubility in alkalies, and alſo in alcohol and ether. In theſe two latter properties all the ſpecies of wax differ from the concrete oils, with which in other reſpects they have a very ſtrong reſemblance.

BEES WAX is the ſubſtance, excreted from the body of the bee, of which theſe inſects conſtruct their cells, both thoſe for containing honey and for the lodgment of their young. It is collected for the uſe of man wherever bees are kept. A young hive will yield at the end of the ſeaſon about a pound of wax; and an old hive about twice as much. The colour of wax when freſh from the bee is nearly white, but it ſoon grows conſiderably yellow in the hive, or if very old is of a dark brown. The origin of the wax we ſhall mention afterwards. The fineſt wax is found to be made in dry, heathy, or hilly countries, but it is decidedly inferior in parts full of vineyards. The loaves of common bees wax are made immediately from the honeycomb, by a ſlight preparation. The combs are firſt emptied of all the honey that can be collected by the preſs, and are then either ſoaked for ſome days in clear water to extract all the remaining honey, or in ſome parts they are broken down and ſpread on a ſheet in the neighbourhood of the hives, and in time the bees ſuck out all the honey that is left, and reduce the wax to ſmall pieces like bran. The whole of the wax is then melted in a clean copper with boiling water, and ſtrained by a preſs through cloth bags, to free it from every impurity. It is then caſt into cakes, in which form it is received by the wax-refiners.

The wax of theſe cakes, which is the ordinary bees wax of the ſhops, is a pale yellow ſubſtance, of an agreeable honey-like ſmell, ſoft, and ſomewhat unctuous to the touch, but without ſticking to the fingers, in winter becoming conſiderably hard and tough, and melting at about 142°.

This yellow colour and the ſmell of wax are entirely taken away by expoſing it, when divided into thin laminæ, to the united action of the light and air, and by this means it becomes perfectly white, ſcentleſs, ſomewhat harder and leſs greaſy to the touch, and in this ſtate it is employed for candles and many other purpoſes. The proceſs of bleaching wax is the following:[a] The yellow wax is firſt broken into ſmall pieces and melted in a copper cauldron along with a very little water, juſt ſufficient to prevent the wax from burning, for it is of importance to uſe no more heat than is neceſſary. The plug of the copper is then drawn, and the melted wax and water fall together into a veſſel below, where it is covered with a thick cloth to keep in the heat for ſome time, that the water and impurities may ſettle. The clear melted wax is then ſuffered to flow into a veſſel with the bottom full of ſmall holes about the ſize of a grain of wheat, whence it falls in ſmall ſtreams upon a cylinder kept conſtantly revolving over water in which it partly dips, by which the wax is immediately cooled, and at the ſame time drawn out into thin ſhreds or ribbands. Theſe ſhreds are then ſpread upon cloths ſtretched on large frames, which are ſupported a foot or two from the ground, and after expoſure to the ſun and air for ſeveral days, with frequent turning, their yellow colour nearly diſappears. The half-bleached wax is then heaped up in a ſolid maſs, and allowed to remain for a month or ſix weeks, after which, to give it compleat whiteneſs, it is re-melted, and ribbanded, and bleached as before, till it is entirely void of colour and ſmell. Some manufacturers add in the re-melting either alum or cream of tartar, or ſometimes milk, all of which are ſuppoſed to increaſe the whiteneſs and ſolidity of the wax.

Inſtead of ſpreading the ribbands of wax on cloths, ſome employ a broad courſe of bricks laid evenly, which are frequently watered to prevent the wax from melting by the heat of the ſun abſorbed by the bricks.

Wax is frequently adulterated by tallow, ſuet, or animal fat of ſome kind or other. This gives the mixture a greater fuſibility, ſo that when ribbanded and expoſed to a hot ſun it is extremely apt to cake. It alſo takes away from it the ſemi-tranſparency, which is a diſtinguiſhing property of pure bleached wax; for though fine tallow is full as white as wax, it is always a dead opake white. The adulteration may alſo be detected by boiling alcohol, which diſſolves wax but not tallow.

Bleached wax burns with a very pure white light, and gives no offenſive ſmell, and very little ſmoke compared with tallow. Being leſs fuſible than tallow it requires a ſmaller wick. Bleached wax melts at about 155° or 7° higher than the unbleached. Its ſpecific gravity is leſs than that of water, being about .96.

Alcohol has no ſenſible action on wax when cold, but on boiling this fluid, it diſſolves rather leſs than $\frac{1}{20}$ of its weight of wax, the greater part of which ſeparates when cold in the form of white bulky flocculi, and what little remains in ſolution is entirely precipitated by water.[b]

Sulphuric ether diſſolves wax when a little heated, and much more copiouſly than alcohol does, but the greater part is alſo ſeparated by cooling and the remainder by water.

When wax is boiled in cauſtic potaſh, the fluid becomes turbid, but after a time moſt of the wax riſes to the ſurface, and in a flocculent form. The clear alkaline liquor then holds in ſolution a portion of the wax, which may be ſeparated by an acid, and the part that remains on the ſurface is ſo far ſaponified as to have loſt its inflammability, and to be as ſoluble in pure water as white ſoap is, and again precipitable by acids nearly in its original form, with its inflammability reſtored. Pure ammonia acts nearly as the fixed alkalies, but the reſulting ſaponaceous ſcum is leſs ſoluble in water.

If wax is diſtilled with a heat greater than that of boiling water it is decompoſed.[c] A ſmall quantity of water firſt riſes which is followed by a very penetrating volatile acid (probably a modification of the acetous) accompanied with a little very fluid and odoriferous oil. As the diſtillation advances the acid becomes ſtronger, and the oil much more copious and thicker, till at laſt its conſiſtence is ſuch as to become ſolid in the receiver, when it is called *Butter of Wax*. When the heat is raiſed to low redneſs, and every thing volatile has come over, a ſmall quantity of coal is left behind. The oil and butter of wax, if again diſtilled in a gentle heat, become more and more fluid, and at the ſame time acquire a greater ſolubility in ſpirit of wine, and this oil never hardens by keeping.

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[a] Encycl. Arts et Met..

[b] Boſtock in Phil. Journ. Vol. iv. p. 184.

[c] Macquer's Dict.

Wax is ſoluble abundantly in the fixed oils, and when melted with them an uniform maſs is produced, whatever be the proportions of each, the conſiſtence of which is intermediate between the two. Oil and wax ſometimes with ſpermaceti, form the baſis of moſt of the cerates and ointments uſed in pharmacy.

The eſſential oils diſſolve wax but ſparingly.

The action of the acids upon yellow wax has been examined in a ſeries of experiments by Beckman,[d] particularly with a view to their bleaching power. The ſame ſubject has alſo been followed by Sennebier,[e] who has added ſome remarks on the effect of light and other ſuppoſed decolouring agents.

The operation of light was thus ſhewn: ſome yellow wax was melted and thinly ſpread on a plate of glaſs; a ſimilar plate was laid upon it when hot, and the edges of the plates were cloſed with ſealing wax. The bees-wax therefore was deprived of the acceſs of air, and it was placed in the ſun, and expoſed to its light for four or five hours daily. Another quantity of wax was incloſed between plates in a ſimilar manner, but kept in the dark. In two days the wax kept in the ſun began to bleach, and in a month's time the whole, where it did not exceed two lines ($\frac{1}{6}$ of an inch) in thickneſs, was quite white, whilſt no change whatever took place in that which was kept in darkneſs.

If thin ſhavings of wax are immerſed in either of the three mineral acids,[f] a little dilute, in a few hours the yellow colour diſappears, and the wax is rendered partly white, partly pellucid. No further change takes place, nor is the colour of the acid at all altered (unleſs heat be applied) for many weeks. The bits of wax are however much hardened by remaining in the acid, ſo as to rattle when ſhaken againſt the ſides of the glaſs, and by briſk agitation they may be broken down into very minute white flocculi. This change takes place much the moſt rapidly in the nitric acid, or in the nitro-muriatic, and it is compleatly effected in an hour or two. It alſo happens when wax is melted in nitric acid, though leſs rapidly. This circumſtance led the author of theſe experiments to expect that ſomething might be done in the large way in bleaching wax by nitric acid, but this hope proved fallacious, for on removing the wax from the acid and melting it in water, (which is neceſſary to extract the acid) the wax reſumes a yellow colour, and the water alſo becomes of a high brown yellow. By repeatedly melting the wax in water (without any additional acid) it becomes more and more yellow, and at the ſame time grows harder and much more fuſible than at firſt.

Neither is the vapour of burning ſulphur, which ſo ſpeedily bleaches ſilk and many other ſubſtances, more ſucceſsful in depriving wax of its colour.

The effect of cauſtic alkali upon wax has been already mentioned. When yellow wax has long been ſwimming in a ſolution of carbonat of potaſh, it becomes grey, and this colour is entirely changed to a milk-white by ſubſequent digeſtion in nitric acid, and the wax reſumes its whiteneſs.

Profeſſor Beckman then tried the whitening effect of fuller's earth, or ſome ſimilar ſubſtance, being led to uſe it from the known power which it has in whitening and purifying tartar. Some yellow wax was melted, and a quantity of this earth finely powdered was ſprinkled in. The wax was then melted out, and being fuſed in water it appeared grey, like wax half-bleached in the common way, which the author ſuppoſes would ſave much time in the whole proceſs.

A few words may be added as to the origin of wax. It is uſually ſuppoſed that the wax is the *pollen* of flowers, which the bees viſibly collect on their thighs, and afterwards elaborate in ſome unknown way. The great difference between wax and this matter which the bees collect, has however been long remarked. When examined by the microſcope this little maſs of pollen is obviouſly compoſed of a number of hard grains compreſſed together, and if it is laid on a hot plate, it does not melt as wax would do, but ſmokes, dries, and is reduced to a coal, and if kindled it burns without melting.

Some late very curious experiments of Huber,[g] one of the moſt celebrated apiariſts in Europe, has further ſhewn that the pollen has no ſhare whatever in the formation of wax, but that this latter ſubſtance is produced indiſcriminately from honey, ſugar, or any other ſaccharine matter which ſerves as food for the bees. The details of theſe experiments hardly belong to chemical ſubjects; it is ſufficient to mention that they were performed by confining ſeparate ſwarms of bees within their hives, and feeding one with honey, another with muſcovado ſugar, another with treacle, another with refined ſugar, in all of which abundance of fine wax was produced: and on the other hand, by feeding another hive only with pollen and fruits, no wax whatever was formed, though the bees remained for a week in their confinement. Other obſervations and experiments by this ingenious naturaliſt ſtill further explain this ſubject, by ſhewing what is the real uſe of the pollen, namely, to afford ſuſtenance for the larva of the bee the moment it is hatched.

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[d] Nov Comment. Soc. Reg. Gotting. Vol. v. for 1774.

[e] Journ. de Phyſ. Tom. xxxviii. for 1791.

[f] Beckman.

[g] Journ. de Phyſ. Tom. lviii.

The Myrtle Wax is a concrete ſubſtance moderately hard, nearly of the conſiſtence of bees-wax, and of a dingy green colour: it is contained in abundance in the berries of the *Myrica latifolia*, a fragrant buſhy ſhrub with leaves like the myrtle, which grows abundantly in many parts of North America: it is alſo procured from another ſpecies of the ſame genus, the *Myrica Gale* which is common in boggy moſſes in ſeveral counties of England.

A very large quantity of the myrtle wax is extracted from this ſhrub in Louiſiana, by collecting the berries, boiling them with water, and bruiſing them at the ſame time, by which the wax melts out and riſes to the top as a thick oily ſcum, which is eaſily ſeparated. The berries yield about a fourth of their weight of this wax.[h] They contain alſo, according to M. Cadet, a conſiderable quantity of gallic acid.

This wax has been examined chemically both by the above-mentioned chemiſt and by Dr. Boſtock, and it is found to reſemble bees-wax ſo cloſely in the moſt important properties, that they may be claſſed under the ſame genus of chemical bodies. In ſome reſpects however the myrtle wax differs from that of the bee. Its ſpecific gravity is 1.015, ſo that it ſinks in water. It melts at 109°, and when kindled it burns with a clear white flame, and an agreeable aromatic odour, and produces little ſmoke. With alcohol, ether, and the alkalies, its habitudes cloſely reſemble thoſe of bees wax, only it appears to be a little more ſoluble in each of theſe menſtrua. The acids have, when cold, as little effect on the myrtle wax as on that of the bee, and the former is not entirely bleached by digeſtion with nitric acid, but only rendered of a pale yellow. Cauſtic potaſh however in diſſolving it whitens it compleatly. No attempts have yet been made to bleach it in the large way by expoſure to the ſun and air.

The myrtle wax is uſed largely in ſome parts of America, as a material for candles, and on the whole it appears worthy of further attention.

WEIGHTS. See the Appendix.

WELD. In addition to what has been ſaid on the uſe of this plant under the article Dyeing, we may add that the fine delicate yellow which it gives is much employed by the paper ſtainers in this town, and is ſold in the form of hard lumps, conſiſting chiefly of chalk ſaturated with the colouring matter.

The following is given by Meſſrs. Collard and Fraſer as an improved proceſs.[a] Diffuſe any quantity of fine whiting in boiling water, add thereto one ounce of alum for every pound of whiting, which will cauſe a briſk efferveſcence, and ſtir theſe materials well together till all diſengagement of gas has ceaſed. On the other hand, boil in a ſeparate veſſel ſome weld with water juſt enough to cover it, for fifteen minutes, filter the yellow decoction, and then mix it with the whiting and alumine in ſuch proportions as that the earths may appear to be ſaturated with the colouring matter. Then let the mixture remain a day at reſt, and at the bottom will be the precipitated earth firmly united with the colour, and of a fine yellow tinge, which may be conveniently dried on chalk-ſtones.

The weld yellow is a water colour, and is never mixed with oil.

WELDING. Welding is that intimate union produced between the ſurfaces of two pieces of malleable metal when heated almoſt to fuſion and hammered. This union is ſo ſtrong that when two bars of metal are properly welded, the place of junction is as ſtrong relatively to its thickneſs as any other part of the bar. Only two metals are capable of firm union by welding, namely *platina* and *iron*, (which ſee).

WELTER's TUBE. See Appendix of Apparatus.

WERNERITE.

Its colour is intermediate between piſtachia-green and Iſabella-yellow. It occurs cryſtallized in rectangular tetrahedral priſms, terminated by obtuſe tetrahedral pyramids: ſometimes the lateral edges are truncated, forming an octohedral priſm. The cryſtals are ſmall, and laterally aggregated. It is more or leſs ſhining with a luſtre between greaſy and pearly: its fracture is curved lamellar in two directions, paſſing into uneven. It is tranſlucent, and ſomewhat inferior in hardneſs to felſpar. Sp. gr. 3.6.

Before the blow-pipe it intumeſces, and melts eaſily into a white opake enamel. It occurs in the iron mines of Northo in Sweden, and near Arendahl in Norway.

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[h] Cadet, in An. Chim. Tom. xliv.

[a] Phil. Mag. Vol. xiii.

WETZCHIEFER. See Thonschiefer.

WHINSTONE. See Basalt and Trap.

WHITE COPPER. See Copper. *(Alloys of).*

WHITE LEAD, or *Ceruſſe.* See Lead.

WINE.

Under the articles *Fermentation*, *Brandy*, *Alcohol* and *Tartar*, we have already deſcribed (ſufficiently at length for a manufacture not uſed in this country) the method of converting the grape juice into wine, and of procuring ardent ſpirit from the latter by diſtillation; we ſhall therefore in this place only mention the analyſis of wine as given by M. Chaptal in his elegant and valuable memoirs on the culture and produce of the vine[a].

All wines contain an acid, alcohol, tartar, extract, aroma, and a colouring matter. The preſence and nature of each of theſe principles may be aſcertained in the following way.

1. *Acid.* All wines, even the ſofteſt and mildeſt, redden litmus, and therefore contain an acid. This abounds however chiefly in the thin wines of wet and cold climates, where the grape juice or *muſt* contains but a ſmall portion of ſugar. When wine has been boiled to extract the brandy, the liquor that remains in the ſtill, and is thrown away as uſeleſs, is a ſour nauſeous fluid with an acrid and burnt flavour. When filtered and allowed to remain at reſt for a time, it depoſits a good deal of extractive matter, becomes covered with mould, and then contains a notable quantity of acetous acid, which may be ſeparated by diſtillation. The acid is however not entirely acetous, at leaſt not till after ſtanding a conſiderable time, for it precipitates and forms an inſoluble ſalt with lime water, and with the ſoluble ſalts of ſilver, lead, and mercury, and appears to be the *Malic* acid mixed with a little *Citric*, both of which are converted into vinegar by ſpontaneous decompoſition. The wines that contain the greateſt quantity of theſe acids yield the worſt brandy, nor is there any method yet known of ſeparating or neutralizing the acid without materially injuring the quality, or leſſening the quantity of the ardent ſpirit.

2. *Alcohol.* The exiſtence of this principle and mode of extraction by diſtillation has been fully deſcribed under the article *Brandy.* The quantity of alcohol varies prodigiouſly. The ſtrong, rich, full-bodied wines of the warmer vine countries will yield as much as a third of ardent ſpirit; whilſt the thin light wines will often give no more than about $\frac{1}{16}$th of the ſame ſtrength.

3. *Tartar.* This ſubſtance has alſo been fully deſcribed in its proper place. Tartar is not altogether a product of the fermentation of wine, ſince it is contained in muſt, though in ſmall quantity.

4. *Extract.* Muſt contains an abundance of extractive matter, which materially aſſiſts the fermentation, and is afterwards found, in part at leaſt, in the lees, but another portion may be obtained from the wine by evaporation. It is alſo extract that mixes with and colours the tartar. By age the quantity of extractive matter diminiſhes.

5. *Aroma.* All wines poſſeſs a peculiar and grateful ſmell, which would indicate a diſtinct aromatic principle, but it has never been exhibited in the form of eſſential oil, or condenſed in any ſmaller quantity by diſtillation or any other mode. To give wine all its aroma it ſhould be fermented very ſlowly.

6. *Colouring Matter.* The huſk of the red grape contains a good deal of colour, which is extracted when the entire fruit is preſſed, and becomes diſſolved in the wine when the fermentation is compleat. Many ſubſtances will ſeparate the colour. If lime-water is added to high-coloured wine a precipitate is formed of malat of lime that carries down with it all the colouring matter, which cannot again be ſeparated either by water or alcohol. But if wine alone is evaporated gently to dryneſs, and the reſidue treated with alcohol, the colouring matter diſſolves therein. We may add too, that the natural colour of wine is entirely and ſpeedily deſtroyed by the addition of hot well-burnt charcoal in pretty fine powder. The colour of red wine in the ſtate in which we receive it is not entirely that of the grape, but is given by other colouring ſubſtances, which however are quite innoxious.

WITHERITE. *Barolite,* Kirw. *Native carbonat of barytes.*

Its colour is yellowiſh-grey, paſſing into greyiſh-white and pale wax-yellow. It occurs in maſs, diſſeminated, and rarely cryſtallized. Its forms are 1. a flattened hexahedral priſm terminated by hexahedral pyramids.

2. The ſame, with the lateral edges of the priſm and pyramid truncated.

3. A pyramidal dodecahedron.

The cryſtals are in general very ſmall, either implanted in the maſſive varieties of this mineral, or grouped in bundles: their ſurface is generally rough. The longitudinal fracture of Witherite is between radiated and lamellar, and has a ſhining luſtre; the croſs fracture is fine-grained uneven, and glimmering with a greaſy luſtre. Its fragments are wedge-ſhaped. The maſſive variety often preſents ſcapiform and wedge-ſhaped diſtinct concretions. It is tranſlucent, paſſing to ſemi-tranſparent. Its hardneſs is about equal to that of fluor: it is brittle and eaſily frangible. Sp. gr. 4.3.

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[a] An. Chim. Tom xxxv, xxxvi, and xxxvii.

Before the blow-pipe on charcoal it firſt crackles a little, and then melts into a whitiſh enamel. Strong nitric acid has little or no effect upon it, but when very diluted, this menſtruum diſſolves it readily with a copious efferveſcence.

When pure it conſiſts of

78	Barytes
22	Carbonic acid
100	

A ſpecimen from Anglezark afforded Klaproth

98.246	Carbonated barytes
1.703	Carbonated ſtrontian
0.043	Alumine with a little iron
0.008	Carbonated copper
100.	

Witherite is an active poiſon to animals.

It was firſt diſcovered by Dr. Withering at Anglezark, in the north of Lancaſhire: it has ſince been found in the Schlangenberg in Siberia, and alſo near Neuberg in Upper Stiria.

It occurs at Anglezark in veins in ſlate, accompanied by heavy ſpar, galena, blende, and calamine.

WOAD. This valuable dyeing drug (the uſe of which however has been a good deal ſuperſeded by indigo) gives a full bodied and very faſt blue to wool, but not very bright, ſo that it is always mixed with indigo at preſent. The mode of preparing the woad-vats is mentioned under the article *Dyeing*, p. 373.

The mode of cultivating and preparing the woad in Thuringia is thus given by Wedelius.[a] Woad requires a very rich deep ſoil well manured and tilled. The ſeed is put in the ground in February. In June the leaves turn yellowiſh, and the plant begins to flower, which is the time for gathering the firſt crop, which is done by mowing down the whole plant cloſe to the ground. It is then rinced in water and ſpread out in the ſun, and when dry enough it is ground in mills to a fine paſte, which is further dried by ventilation. This paſte is then made up into cakes, which are heaped upon each other in a covered room, whereby they ſoon ferment, heat, and exhale a moſt penetrating nauſeous ammoniacal odour which ſpreads to a great diſtance: this fermentation is kept up for a ſufficient time, occaſionally watering the cakes when the heat is too great, till the whole falls into a coarſe powder, in which ſtate the woad is again made up into balls, and is ready for uſe.

The root of the plant throws out a freſh crop of young ſhoots which are fit to cut in about ſix weeks after the firſt harveſt, and are managed in the ſame way, and ſometimes, if the ſeaſon continues dry and warm, a third crop may be got in the ſame year, but this is much inferior to the two firſt.

The fermentation of the woad plant is peculiarly violent, and attended with an uncommonly nauſeous ſmell, and the production of a large quantity of ammonia. Much practical ſkill is required in the management of it, for if ſuffered to heat too much the whole is converted to a black effete maſs, and the blue colour, for which the plant is cultivated, is totally deſtroyed. The fermentation is both moderated and prolonged by the great hardneſs of the cakes, which cannot eaſily be broken up till they crumble to pieces of themſelves by their ſpontaneous action.

When woad is diſtilled *per ſe*, it gives out a conſiderable quantity of ammonia along with the other principles common to vegetable matter. Nitric acid has but little action on it, in which it differs remarkably from indigo. The colour however is totally deſtroyed. According to the imperfect experiments of Dijonval[b], ſulphuric acid acts on woad with great vehemence, cauſing much tumefaction and diſengagement of gas, and a ſolution is at laſt effected, which, diluted with water, is a faint undefinable green, without any thing of the fine blue which diſtinguiſhes the ſulphat of indigo. When woad is diffuſed in water and kept for a time it ſpeedily putrefies, and gives a more penetrating and fetid ſmell than moſt vegetable or even animal matter under ſimilar circumſtances.

WOLFRAM. See TUNGSTEN.

WOOD. *Bois*, F. *Holz*, G.

The wood of vegetables conſiſts obviouſly of a denſe congeries of fibres abundantly impregnated with a variety of the natural juices of the plant, ſuch as mucilage, reſin, colouring extract, eſſential oil, ſugar, &c. all of which may be obtained from one or other kind of wood, by applying thoſe menſtrua which diſſolve theſe ſubſtances in their natural ſtate. But after the action of theſe menſtrua has been exhauſted, after wood has been long boiled in water, alcohol, and weak acids, a ſubſtance remains, which is not in any degree acted on by theſe, which burns in the open air without melting, but with much flame and a penetrating acid vapour, and leaves at laſt only a ſmall quantity of white earthy aſh, from which a ſmall portion of alkali may be extracted. This ſubſtance is conſidered as the pure woody fibre, and has ſome title to be conſidered as a diſtinct vegetable principle, as it has ſome properties peculiar to itſelf. The earth and alkali (or neutral ſalts, which, by combuſtion, furniſh the alkali) muſt however be reckoned as foreign to the pure ligneous fibre, though they cannot be extracted without entire diſorganization of the wood.

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[a] Ephem. Nat. Cur.

[b] Journ. Phyſ. Tom. xi.

It is not eaſy to extract all the ſoluble parts of freſh wood, ſuch as the reſin and colouring matter, without firſt reducing it to very fine duſt, for M. Sennebier[a] found that even the thinneſt ſhaving of entire wood long reſiſted the action of common menſtrua. But after bruiſed wood has been long boiled alternately in water and alcohol, and again thoroughly dried, it then loſes ſo much of its coheſion that it may be reduced to very fine powder, from which a ſubſequent application of the ſame liquors will compleat the extraction of every thing ſoluble.

The reſidue, which is as pure woody fibre as can be obtained, when heated ſtrongly in a retort, without addition, yields a conſiderable quantity of a red pungent acid liquor, which has long been conſidered as a peculiar acid, and has been called the *pyroligneous*, but later experiments render it probable that it is little elſe than the *acetous* holding ſome empyreumatic oil in ſolution. Its general properties are deſcribed under the article *Acetous Acid (Empyreumatic)*. But it is to be obſerved that it is commonly procured by the ſimple diſtillation of wood unprepared by any previous proceſs, and of courſe may be mixed with a portion of all the other ingredients of wood which are volatile by fire and again condenſible in a liquid form; nor do we know of any experiments made in a ſufficiently large way, on the acid yielded by wood on which the action of water and alcohol has previouſly been exhauſted.

The pure ligneous fibre is decompoſed by being heated with ſtrong nitric acid, and yields a very conſiderable quantity of oxalic and malic acid. The cauſtic alkalies alſo ſoften, and finally diſſolve it.

The ſurface of wood is readily ſtained by a variety of ſubſtances, and if theſe are allowed to remain in contact with it they ſink into the ſubſtance of the wood which often produces a very agreeable effect in cabinet work, and ſometimes gives to ordinary wood a very good reſemblance of the more expenſive coloured woods of foreign countries.

The following experiments to this purpoſe have been made by Beckman.[b] Some maplewood was firſt ſawed into thin ſlips about $\frac{1}{12}$ of an inch in thickneſs. One of theſe was immerſed in a ſolution of dragon's blood in oil of turpentine. After a conſiderable time the wood had abſorbed ſo much of the reſin as to ſink in the liquor, and it was then of a fine mahogany colour, ſhewing the veins of the wood by a lighter ſhade of red. Another ſlip of wood was dyed in the ſame manner in a ſolution of gamboge in oil of turpentine, which gave a fine yellow, and by a mixture of gamboge and dragon's blood in different proportions, a number of beautiful tints may be produced. Beech-wood was found to take the colour ſooner, but it was leſs brilliant. A ſolution of theſe reſins in alcohol alſo anſwered very well. With theſe kinds of ſubſtances, however, it is neceſſary in order to produce a good colour, either to boil the wood in the liquor, or at leaſt to continue the digeſtion for a conſiderable time, ſo that they can only be employed to great advantage with ſmall pieces, ſuch as are uſed for the finer kinds of inlaying or veneering. But many ſaline and metallic ſolutions produce a more ſpeedy effect in changing the colour of wood, which may be applied to a ſurface of any extent.

All the white woods are rendered much whiter by being ſoaked in a ſolution of alum. This is probably owing to a decompoſition of the ſalt, and a depoſition of its earth within the pores of the wood in very fine diviſion.

A deep black is given to wood in various ways. Oak and other woods that abound in gallic acid receive a black from the ſolutions of iron, but theſe woods are comparatively rare.

If concentrated ſulphuric acid is ſmeared over the ſurface of wood it blackens it very ſpeedily, and this colour ſpreads deep within the wood in a few hours, its ſurface being at the ſame time covered with a tenacious froth. When this is thoroughly waſhed off, and the wood dried, the ſurface is of a deep charcoal black, and hard enough to take a good poliſh; but it is not eaſy to get rid of every particle of the acid. A much finer and better black is given by firſt ſoaking the wood in any ſolution of lead, and afterwards for a day or two in a ſolution of arſenical liver of ſulphur, made by boiling in water a mixture of two parts of quicklime and one of orpiment. Probably the ſimple ſulphuret of lime would anſwer as well. All the other metallic ſolutions that naturally blacken with the ſulphurets will anſwer the ſame purpoſe, ſuch as thoſe of ſilver, biſmuth, and iron, but lead ſucceeds the beſt.

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[a] Journ. Phyſ. Tom. xxxviii.

[b] Nov. Com. Soc. Gotting. Tom. vii.

With the woods that contain no gallic acid a yellow-brown dye, varying to brown-red, is given by ſmearing them over a few times with a ſolution of iron in dilute nitric acid.[c] This dye is very permanent, and does not change by the action of light or air.

A greeniſh hue may be given by the ſolutions of copper, but it is difficult to make wood take it equally, or to give any depth of colour by this metallic ſolution.

Different hues may be given by ſtrong decoctions of the colouring woods and other dyes mixed with alum, which need not be here enumerated.

In all the above proceſſes, and particularly where any ſaline or metallic ſolution is employed, the natural gloſs of the wood is much impaired, which requires that it ſhould be finiſhed with linſeed, or amber, or any ſimilar varniſh, which has the effect both of rendering the dye more permanent, and of much increaſing its beauty.

WOOD, *petrefied.*

Wood in ordinary circumſtances, whether upon the ſurface of the earth or buried under it, is by degrees, by the concurrent action of air and water decompoſed; its texture is broken down, the connexion between the ſeveral vegetable principles of which it conſiſts is diſſolved, its ingredients enter into new combinations, and no veſtige remains either of its organization or chemical properties. Sometimes however it happens that the external figure and internal arrangement are preſerved while the chemical properties have undergone very notable alteration, in conſequence of which the natural decay is prodigiouſly retarded, and ſometimes even wholly ſuſpended. Wood that has undergone this change is ſaid to be petrefied, or mineralized.

There are three ſubſtances by which this change is brought about, namely pyrites, oxyd of iron, and ſiliceous earth in the form of agate or hornſtone. Theſe conſtitute ſo many ſpecies of petrefied wood.

The *pyritous foſſil wood* occurs principally in the independent coal formation; it is compoſed entirely of common pyrites, often in a ſtate of ſemi-decompoſition: it appears to contain no ligneous particles, but retains with conſiderable exactneſs the external figure, and in ſome degree the internal organization of wood. The reaſon why this ſpecies preſents a leſs ſtriking reſemblance to wood than the others do, is probably the ſtrong cryſtalline polarity which pyrites poſſeſſes; in ſplitting longitudinally a piece of pyritized wood it not unfrequently happens that the fibres repreſenting the concentric layers of wood are compoſed of minute cubes laterally aggregated to each other.

The *ferruginous foſſil wood* is found in hematite, and eſpecially in argillaceous iron ore. Externally it preſents the appearance of trunks and branches, and its internal texture has a cloſe reſemblance to that of wood. In its chemical compoſition it does not appear to differ materially from common argillaceous iron ore.

But *agatized wood* is that which has been the moſt examined. It has been made a diſtinct mineral ſpecies by Werner, who has given it the name of HOLZSTEIN or Woodſtone, of which the following are the characters.

Its colour is aſh-grey, paſſing into greyiſh-black, yellowiſh, browniſh, and blood-red: the colours run into each other forming clouds and ſtripes in a longitudinal direction. It occurs in the form of trunks, branches and roots, and preſents in the utmoſt perfection the internal organization of wood, not only the longitudinal fibres and concentric layers being viſible, but even the knots and medullary proceſſes. Its internal luſtre is various, being between gliſtening and dull. Its croſs fracture is imperfectly conchoidal, its longitudinal fracture is ſplintery and fibrous. It is moderately tranſlucent; is harder than glaſs, and gives fire with ſteel, but is eaſily frangible.

It occurs in ſand and ſandſtone in various countries, eſpecially in the hill St. Symphorien, near Etampes in France, in Saxony, Bohemia, and Hungary; near Loch Neagh in Ireland, in the beds of ſandſtone that lie above the fuller's earth near Woburn in Bedfordſhire, and alſo in the ſandy deſarts to the weſt of Egypt.

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[c] Repertory, Vol. xiv.

It not unfrequently happens that agatized wood before the petrefying proceſs has begun, has been corroded by worms, in which caſe not only the perforation is filled with ſiliceous matter, but even the ſubſtance of the worm itſelf has been compleatly agatized.

Agatized wood diſcovers ſlight traces of its origin by affording a few drops of a watery empyreumatic liquor by diſtillation: it conſiſts however for the moſt part of ſilex.

The origin of petrefied wood is generally attributed to the gradual infiltration of the petrefying ſubſtance, but to this theory, however ſimple and ingenious, there are many important objections.

WOOD-STONE. See the preceding article.

WOOD-OPAL. See Opal.

WOOL. *Laine*, Fr. *Wolle*, G.

This ſubſtance, the material of ſuch important manufactures, poſſeſſes ſome curious chemical properties, none of which however are much illuſtrated by the various operations performed on it in manufacture, almoſt all (that of dyeing excepted) being purely mechanical proceſſes.

Some of the ſimple chemical properties of wool have been examined by M. Achard,[a] and compared with the correſponding properties of the hair of different animals. The copious generation of *oxalic acid* by treatment of wool with nitric acid, has been particularly deſcribed and explained by M. Berthollet in his beautiful reſearches on animal matter; and the great ſolvent power of the cauſtic fixed alkalies, has been happily applied to ſome uſe by M. Chaptal as a ſaponaceous compound.[b]

Wool in the ſtate in which it is taken from the ſheep is always mixed with a great deal of dirt and foulneſs of different kinds, and in particular is ſtrongly imbued with a natural ſtrong-ſmelling greaſe. Theſe impurities are got rid of by waſhing, fulling, and combing, by which the wool is rendered remarkably white, ſoft, clean, light, and ſpringy under the hand. When boiled in water for ſeveral hours in a common veſſel, wool is not in any way altered in weight or texture, nor does the water acquire any ſenſible impregnation.

A little action is ſhewn between water and wool by boiling for an hour in a high heat, with a Papin's digeſter,[c] the water acquires a ſmell like that of raw wool, and the wool is ſomewhat whitened, but its weight is not ſenſibly changed, nor its texture materially altered. In this reſpect it differs ſomewhat from hair, the texture of which is much ſoftened whilſt it is wet, by boiling in a digeſter, but when dry it becomes quite criſp and brittle.

Sulphuric acid added cold to wool produces neither heat nor any vapour, but after a few hours the acid blackens, and the wool loſes its texture, becomes ſoft and gelatinous, and finally diſſolves, forming a black thick acid liquor.

The action of the nitric acid on wool is undoubtedly the moſt curious. When cold, this acid only diſengáges a large quantity of azotic gas, but when warmed, much nitrous gas is given out, and at leaſt two new acids are formed, viz. the *malic* and the *oxalic*, the latter is in greater abundance than even from ſugar and nitrous acid, or any other hydro-carbonous baſis. A ſmall ſcum of a peculiar oil always ariſes during the action of nitrous acid on theſe animal ſubſtances. See the article Oxalic Acid.

Muriatic acid when boiled on wool ſimply diſſolves it. The ſolution is dark brown, and is not changed by the addition of water.

The action of the oxymuriatic acid has not been further examined than to diſcover that it does not whiten wool as it does cotton, but on the contrary, turns it to a pretty deep yellow; which may occaſionally furniſh an uſeful method of diſtinguiſhing the fibre of wool from that of cotton in any kind of cloth where they may be mixed.

No effect is produced by boiling wool in the oils, fixed or eſſential, or in alcohol.

The carbonated alkalies have little action on wool, but the cauſtic fixed alkalies when digeſted with it ſpeedily weaken its fibre, reduce it to a ſoft gelatinous pulp, and finally make a perfect ſolution. The alkali at the ſame time loſes its alkaline properties as it does in common ſoap. This ſaponaceous ſolution of wool is made for experiment in a few minutes by boiling bits of wool or flannel in a cauſtic alkaline ſolution, and it has been recommended by Chaptal to be employed inſtead of common ſoap in cleanſing cotton and other goods in manufactures, as by this means a number of refuſe bits and clippings of wool and woollen cloth which are now thrown away may be put to ſome uſe. This ſoapy ſolution does not lather well when agitated with water, nevertheleſs it acts very powerfully in cleaning cloth. It has a ſtrong and ſomewhat offenſive ſmell, which is left at firſt in the cloth, but goes off by ſhort expoſure to the air.

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[a] Mem. de l'Acad. de Berlin, for 1782.

[b] An. Chim. Tom. xxi.

[c] Achard.

M. Achard diſtilled *per ſe* in a retort one ounce of wool, with a heat gradually increaſed to ignition. There was left in the retort 2½ drams of a coaly reſidue; the neck of the retort was lined with a black ſhining ſoot; beyond which was a ſaline ſublimate; and in the receiver was about 2 drams of an empyreumatic oil, together with ſome neutral ammoniacal ſalt, the nature of which was not aſcertained.

WOOL *Philoſophical*. See ZINC.

WORMWOOD, *Salt of*.

The purer kinds of ſalt of tartar or carbonat of potaſh were often termed ſalt of wormwood, particularly in medicine, the aſhes of this plant yielding an abundance of this alkali. See *Carbonat of Potaſh*.

WORM-TUB. A part of the common diſtilling apparatus. (*See the Appendix.*)

WOULFE's APPARATUS. (*See the Appendix.*)

WURFELSPATH. See Anhydrous Selenite, p. 547. Vol. 1.

Y

YEAST. See FERMENTATION.

YELLOW (*Naples*).

The Naples Yellow (*Giallolino*) is a fine pigment long prepared at Naples, which has the appearance of an earth, is very friable, heavy, porous, not alterable by expoſure to air, and of a pale orange-yellow colour. When heated it exhales no ſenſible vapour, melts when red-hot, but undergoes no other change except that the colour becomes deeper Boiling water and acids extract a portion from it, but do not diſſolve it entirely.

This pigment (the preparation of which is kept ſecret) has been examined by ſeveral chemiſts, but no accurate analyſis has been made of it. Fougeroux ſhewed that it was a metallic oxyd by reducing it with a proper flux, and eaſily obtained a regulus from it, which conſiſted of lead and antimony.[a] Beckman and Couret have confirmed this compoſition. A proceſs which produces a ſimilar pigment is thus given by Couret.[b] Mix together 12 oz. of ceruſſe, 3 oz. of diaphoretic antimony, of alum and ſal-ammoniac each one ounce, heat them for a conſiderable heat below redneſs, and afterwards in a red heat for three hours longer, after which the maſs will have acquired a beautiful yellow colour.

The Giallolino is little employed in this country, its uſe being ſupplied by *Turner's Patent Yellow*, prepared from LEAD in the manner deſcribed under that article.

YELLOW EARTH. *Gelberde*, Wern. *Terre jaune*, Broch.

Its colour is ochre-yellow; it occurs in maſs; it is dull or at moſt feebly glimmering. Its fracture in the great is ſlaty, but in ſmall is fine-grained earthy, paſſing into imperfectly conchoidal. It is very ſoft, almoſt friable; it acquires a poliſh by friction; ſtains the fingers, and is ſomewhat unctuous to the touch, it adheres ſlightly to the tongue, and is of little ſpecific gravity.

It is employed in the arts as a pigment.

It forms beds in clay, and ironſtone, at Wehrau, in Upper Saxony.

YTTRIA. See GADOLINITE.

Z

ZAFFRE. See COBALT.

ZEICHENSCHIEFER. See THONSCHIEFER.

ZEOLITE. *Zeolith*, Wern.

Of this mineral there are the three following ſubſpecies.

1. *Subſp.* Radiated Z. *Strahliger, Z.* Wern. *Meſotype*, Hauy.

Its colour is yellowiſh-white, greyiſh, reddiſh and ſnow-white. It occurs maſſive, globular, and cryſtallized. Its primitive form is a rectangular, tetrahedral priſm: ſometimes the priſm is terminated by tetrahedral pyramids, the baſes of which correſpond with the faces of the priſm: ſometimes the priſm is compreſſed, and terminated by tetrahedral pyramids ſet on the lateral edges of the priſm; the ſummits of the terminal pyramids are alſo often truncated. The cryſtals are middle ſized and ſmall, and often laterally aggregated, ſo that their ſummits alone are diſtinguiſhable: the lateral planes are ſmooth and ſhining. Internally it is gliſtening, with a pearly luſtre. Its fracture is divergingly radiated, approaching on one hand to foliated, and on the other to fibrous. It preſents longiſh granular diſtinct concretions. It is tranſlucent, paſſing into tranſparent, and poſſeſſes a double refraction. Its hardneſs is ſomewhat ſuperior to that of calcareous ſpar; it is brittle and eaſily frangible. Sp. gr. 2.03 = 2.08.

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[a] Mem de l'Acad. for 1766.

[b] J. Phyſ. Tom. xxxvi.

Before the blow-pipe it intumeſces and melts like borax. It is ſoluble in the mineral acids, and forms with them a gelatinous maſs. Its component parts, according to Vauquelin, are

50.24	Silex
29.3	Alumine
9.46	Lime
10.	Water
99.	

It paſſes into the two following varieties.

Var. 1. Fibrous Z. *Faſriger* Z. Wern.

Its colours are nearly the ſame as the preceding, except that it ſometimes occurs wax-yellow and greeniſh-white. It occurs in maſs, reniform, and in capillary cryſtals. Its fracture is divergingly fibrous, paſſing into ſplintery. In other reſpects it agrees with the preceding.

Var. 2. Mealy Z. *Mehlzeolith*, Wern.

Its colours are yellowiſh and reddiſh-white paſſing into fleſh-red. It occurs maſſive, coralloidal, and incruſting other zeolites. It is dull; its fracture is coarſe earthy, approaching to finely fibrous. It is opake; very ſoft, almoſt friable; very light; and when rubbed with the nail it gives a grating feel and noiſe like burnt brick.

2. *Subſp.* Lamellar Z. *Blattriger* Z. Wern. *Stilbite* Hauy.

Its colour is yellowiſh and greyiſh-white, rarely reddiſh-white. It occurs maſſive, globular and cryſtallized. Its primitive form is a rhomboidal priſm: the other varieties that it preſents are, a ſhort hexahedral priſm, the oppoſite faces alone of which are equal; and a table of ſix equal ſides. The cryſtals are ſmall and middle-ſized, and their ſurface is always ſmooth and ſhining. Internally its luſtre is ſhining and pearly. Its fracture is lamellar, generally ſomewhat curved, and is diviſible only in one direction. It preſents granular and ſometimes curved lamellar diſtinct concretions. When in maſs it is tranſlucent, and when cryſtallized is generally tranſparent. In its other characters it reſembles the preceding ſubſpecies.

It is compoſed, according to Vauquelin, of

52.	Silex
17.5	Alumine
9.	Lime
18.5	Water
97.	

3. *Subſp.* Cubic Z. *Wurfel* Z. Wern. *Analcime* & *Chabaſie* Hauy.

Its colour is greyiſh and yellowiſh-white, and yellowiſh-brown. It occurs in maſs and cryſtallized. The primitive form of its cryſtals is a hexahedron approaching very near to a cube; ſometimes each ſolid angle of the cube is replaced by an obtuſe trihedral pyramid ſet upon the faces of the cube: ſometimes theſe ſecondary faces are ſo large as to obliterate thoſe of the primitive cryſtal, whence there reſults a ſolid with 24 trapezoidal faces. The cryſtals are ſmall and middle-ſized, and are brightly ſhining externally with a luſtre between vitreous and pearly. The internal luſtre is ſomewhat inferior to the external. Its fracture is imperfectly lamellar in three directions, paſſing ſometimes to uneven. Its fragments have a ſtrong tendency to the cubical form. It preſents granular diſtinct concretions; is tranſlucent, paſſing to tranſparent; is ſomewhat harder than glaſs. Sp. gr. 2.7.

It intumeſces before the blow-pipe, but does not gelatinize with acids.

Zeolite occurs principally in the moſt recent floetz trap-formation, eſpecially in amygdaloid and cellular baſalt; in theſe rocks it ſometimes only lines, but often entirely fills up the cavities which they contain. It alſo occurs, though rarely, in primitive greenſtone, and in veins accompanied by galena.

All the above ſubſpecies occur in Scotland, but the largeſt and moſt beautiful ſpecimens come from Iceland and the Ferroe Iſlands: they are alſo met with at Adelfors in Sweden, in various parts or Germany, and very abundantly in the South Sea Iſlands.

ZINC. *Zink*, Germ. *Zinc*, Fr. *Spelter*, *Tutenag*, of the Chineſe.

Zinc is a bluiſh-grey ſemi-ductile metal, fuſible at leſs than a red heat, and combuſtible at the loweſt point of ignition, an extremely brilliant bluiſh-white flame being given out, and the metal being converted into a white flocculent oxyd.

§. 1. *Ores of Zinc.*

Sp. 1. COMMON CALAMINE, Native carbonat of Zinc.

Of this mineral there are the three following ſubſpecies.

1 *Subſp.* Cryſtallized C.

Its colour is greyiſh-white and yellowiſh-grey. It occurs in rhomboids approaching very nearly to the cube, and in longiſh quadrilateral tables: the cryſtals are ſmall and very ſmall; both externally and internally they are uſually ſhining with a luſtre between reſinous and vitreous. Its fracture is ſmall and imperfectly foliated. It is tranſparent, paſſing into tranſlucent; it yields eaſily to the knife but not to the nail. Sp. gr. 4.33.

By ignition in a covered crucible it loſes about 34 *per cent.* It diſſolves totally and with efferveſcence in the mineral acids, and the ſolution does not gelatinize.

It is compoſed, according to an analyſis by Smithſon,[a] of

65.2	Oxyd of zinc,
34.8	Carbonic acid.
100.	

It occurs in veins in ſecondary limeſtone, accompanied by the other ores of this metal, by galena, calcareous ſpar, quartz, &c. It is found in Derbyſhire.

2 *Subſp.* Compact C.

Its colours are greyiſh, greeniſh and yellowiſh white, ochre yellow and yellowiſh brown, the two latter colours however indicate a contamination of iron. It occurs maſſive, cellular, botryoidal, mamillated, reniform and ſtalactitic. Its internal luſtre is gliſtening, between vitreous and reſinous. Its fracture is imperfectly fibrous paſſing to ſplintery and granular uneven. It preſents granular and curved-lamellar diſtinct concretions: the lighter coloured are tranſlucent at the edges. In hardneſs, ſpecific gravity, and chemical characters it differs but little from the preceding ſubſpecies.

It has been analyſed by Smithſon and Bergman[b] with the following reſult.

Sm.		Berg.	
64.8	—	64.	Oxyd of zinc,
35.2	—	28.	Carbonic acid,
0.	—	6.	Water,
0.	—	1.	Oxyd of iron.
100.		101.	

Concerning Bergman's analyſis it may be remarked, that the oxyd of iron is merely accidental, and that the exiſtence of the water is rather inferred than proved, ſo that probably the amount of carbonic acid is ſtated too low.

It occurs in the ſame geological ſituations as the preceding, and is very abundant in Cumberland, Derbyſhire, Flintſhire, and Somerſetſhire in England, and in a multitude of other places.

3 *Subſp.* Earthy C.

Its colour is greyiſh or yellowiſh white. It occurs in maſs, and encruſting the ſurface of other minerals. It is dull; its fracture is very fine grained earthy. It may be ſcraped by the nail; is opake, and adheres to the tongue. Sp. gr. 3.58.

It conſiſts, according to Smithſon, of

71.4	Oxyd of zinc,
13.5	Carbonic acid,
15.1	Water.
100.	

In its other properties it agrees with the preceding ſubſpecies.

It is found in Derbyſhire, in Bleyberg in Carinthia, and elſewhere.

Sp. 2. ELECTRIC CALAMINE.

Its colour is greyiſh, bluiſh or yellowiſh white: it occurs in maſs or cryſtallized. The form of its cryſtals is a compreſſed hexahedral priſm, terminated by low, bevilled, and truncated hexahedral pyramids. The cryſtals are ſmall and very ſmall, either ſolitary or grouped in divergent rays, like zeolite. The luſtre of the cryſtals is ſhining, vitreous; their fracture is imperfectly foliated; that of the maſſive variety is generally diverging fibrous. It varies from tranſparent to opake according as it is cryſtallized or not. It may be ſcratched by a knife, but is conſiderably harder than common calamine. Sp. gr. 3.43. When gently heated it becomes ſtrongly electrical, nor is this property deſtroyed even by a red heat. By ignition its loſs does not exceed 12 per cent, and the cryſtals though they become opake and decrepitate a little, do not fall to powder. It is ſoluble in the mineral acids without efferveſcence, conſiderable heat is extricated, and the ſolution gelatinizes on cooling.

The maſſive variety from Hungary was analyſed by Bergman, and another ſpecimen from Wanlock-Head by Klaproth; that in radiated cryſtals, like zeolite, from Fribourg, by Pelletier;[c] and that in ſolitary cryſtals, from Regbania in Hungary, by Smithſon, with the following reſults.

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[a] Phil. Tranſ. for 1803, p. 17.

[b] Opuſcula, ii. p. 324.

[c] Memoires, i. p. 49.

Berg.	Klapr.	Pellet.	Smith.	
84. —	66. —	36. —	68.3	Oxyd of zinc,
12. —	33. —	52. —	25.	Silex,
0. —	0. —	12. —	4.4	Water,
3. —	0. —	0. —	0.	Oxyd of iron,
1. —	0. —	0. —	0.	Alumine.
100.	99.	100.	97.7	

It occurs in ſecondary limeſtone accompanied by quartz, calcareous ſpar, common calamine, &c.

Beſides the localities above mentioned it alſo occurs in Derbyſhire.

Sp. 3. Blende. *Black Jack*, of the Engliſh miners. *Pſeudogalena.*

Of this there are the two following ſubſpecies.

1 *Subſp.* Foliated B.

Its colour is wax and ſulphur yellow, browniſh and olive green, reddiſh or yellowiſh, or blackiſh brown paſſing into perfect black, alſo hyacinth red, browniſh and blood red. It occurs in maſs, diſſeminated or cryſtallized. Its primitive form is the rhomboidal dodecahedron; the others that it preſents are.

1. The regular octohedron.
2. The pyramidal tetrahedron.
3. Var 1, with all the edges truncated.
4. Ditto, with both the edges and ſolid angles truncated.
5. A ſolid with twelve trapezoidal faces and twelve iſoſceles triangular faces.
6. The preceding variety with four of the ſolid angles replaced by an equal number of equilateral triangles.

The cryſtals are generally ſmall, and ſo impacted together that it is not eaſy to determine their forms: their ſurface is ſmooth and ſplendent. The external and internal luſtre of this mineral is brightly ſhining between reſinous and adamantine, in the darker coloured varieties paſſing to ſemi-metallic. The fracture is ſtrait foliated in ſix directions, but when made acroſs the laminæ is imperfectly conchoidal. Its fragments are angular and pretty ſharp-edged. It preſents granular diſtinct concretions. The lighter coloured cryſtals are tranſparent and tranſlucent, the darker coloured ones and the maſſive varieties are tranſlucent at the edges and opake. Its hardneſs is about equal to that of fluor ſpar; it is brittle and eaſily frangible. Sp. gr. 4.04 = 4.16.

2 *Subſp.* Fibrous B.

Its colour is iron grey mixed with yellowiſh particles; it occurs in cellular, reniform, and ſtalactitical maſſes: externally it is dull: internally it is gliſtening or glimmering; its fracture in one direction is finely and divergingly fibrous; the croſs fracture is conchoidal; it it compoſed of curved lamellar diſtinct concretions. It is opake, moderately hard and brittle. Sp. gr. 3.63.

It has hitherto been found only at Geroldſeck in the Briſgau, in a vein accompanied by galena and heavy ſpar.

The yellow foliated blende is phoſphoreſcent by friction, even under water. Several of the blendes give out an hepatic odour by friction, and ſtill more of them by digeſtion in muriatic acid.

They have been ſubjected to various analyſes, but hitherto not with ſufficient preciſion. The following is a table of the different reſults.

	Zinc	Sulphur	Iron	Lead	Copper	Arſenic	Fluor.ac	Water	Silex	Alumine
Yellow B. by Bergman	64.	20.	5.	0.	0.	0.	4.	6.	1.	0. = 100.
Brown B. by Bergman	44.	17.	5.	0.	0.	0.	0.	5.	24.	5. = 100.
by Dr. Thomſon	58.8	23.5	8.4	0.	0.	0.	0.	0.	7.	0. = 97.7
Black B. by Bergman	45.	29.	9.	6.	0.	1.	0.	6.	4.	0. = 100.
by Lampadius	53.	26.	12.	0.	0.	5.	0.	4.	0.	0. = 100.
Black B. with metallic luſtre by Bergman	52.	26.	8.	0.	4.	0.	0.	4.	6.	0. = 100.
Fibrous B. by Hecht	62.	21.	3.	5.	0.	1.	0.	4.	0.	2. = 98.

Blende occurs in tranſition, primitive, and ſtratified mountains, but principally in the former: it is found in veins almoſt always accompanied by galena, calcareous ſpar and quartz, alſo by iron pyrites, fahlerz, native ſilver, grey antimony, ſpathoſe iron, copper pyrites, heavy ſpar, &c. The Hungarian and Tranſilvanian blendes are often auriferous.

Blende abounds in Britain, and in moſt of the other mining diſtricts of Europe.

§. 2. *Aſſay and Analyſis.*

Common Calamine, beſides carbonat of zinc and water, may alſo contain the carbonats of iron, lead and lime. Its analyſis may be thus conducted. (*a*) Diſſolve the pulverized ore in dilute nitric acid and eſtimate the *carbonic acid* from the loſs of weight during the ſolution. Then carefully neutralize the ſolution by a little cauſtic ſoda and evaporate it gently, adding from time to time a few drops of ſulphat of ſoda as long as any precipitation takes place. (*b*) Having thus cautiouſly brought it nearly to dryneſs, digeſt it in highly rectified alcohol, and afterwards in a little cold water which will take up every thing but the ſulphats of lead and lime. (*c*) Theſe may then be ſeparated by digeſtion in very dilute ſulphuric acid, which will take up the ſulphat of lime, leaving the ſulphat of *Lead* pure. (*d*) Neutralize the muriatic ſolution by ſoda, and evaporate nearly to dryneſs; then add to the reſidue alcohol, which will throw down the ſulphat of *Lime* with a little ſulphat of ſoda, this latter may then be waſhed away by a little cold water. (*e*) The alcoholic ſolution *b* after evaporation to dryneſs may be digeſted in cauſtic ammonia, which will take up the oxyd of zinc and leave behind the oxyd of *Iron.* (*f*) The alkaline ſolution after being ſlightly ſuperſaturated with muriatic acid, is to be decompoſed by a perfectly carbonated alkali, by which the zinc is procured in the ſtate of carbonat, and this, after edulcoration, being diſſolved by ſulphuric acid and the ſolution ignited in a platina crucible affords dry ſulphat of *Zinc*, containing 50 per cent. of oxyd of zinc. (*g*) Thus all the component parts are aſcertained except the water; to determine the proportion of this take a freſh parcel of the ore, weigh it, and then ignite it for half an hour, note the loſs of weight, and transfer the reſidue into muriatic acid; if while it diſſolves in this fluid it gives out any gas let the loſs of weight be noted; then add together the loſſes by ignition and ſolution, deduct from the ſum the known weight of the carbonic acid and the reſidue is *water*.

To analyſe the *electric calamine* diſſolve the pulverized ore in dilute nitric acid, evaporate the ſolution very ſlowly, almoſt to dryneſs, then digeſt it in a large quantity of water and the ſilex will remain undiſſolved. If the ſilex retains the leaſt ochery tinge digeſt it in dilute muriatic acid, by which the adhering oxyd of iron will be taken up. Then decompoſe the muriatic ſolution by a carbonated alkali, and transfer the oxyd thus obtained to the nitric ſolution from which the ſilex has been ſeparated. The reſt of the analyſis is the ſame as already mentioned for common calamine.

The analyſis of *Blende* is conſiderably more complicated. The ſubſtances that have been obtained from it by decompoſition are zinc, iron, lead, copper, arſenic, ſulphur, ſilex, alumine and water; nor is it by any means improbable that the whole of them ſhould coexiſt in the ſame ſpecimen, we ſhall therefore proceed to mention what appears to us as the beſt method of ſeparating theſe ſubſtances from each other.

a For the *Water*; let 200 grs. duly pulverized be put into a ſmall coated glaſs retort and gently ignited for a quarter of an hour; the fluid in the receiver will be water with ſcarcely any perceptible admixture of ſulphurous acid.

b Now take another portion of the ore and digeſt it in repeated portions of dilute nitric acid till every thing ſoluble is taken up; waſh the reſidue, weigh it and ignite it; the *Sulphur* will burn off, and its amount may be eſtimated by the loſs of weight.

c The reſidue, after the ignition of the ſulphur, is to be digeſted in a little nitro-muriatic acid till the inſoluble portion becomes quite white, and is then pure *Silex.*

d To the nitric ſolution (*b*) add a few drops of ſulphated ſoda and evaporate it gently, continuing to drop in from time to time a little ſulphated ſoda as long as any precipitation takes place; when the whole is brought nearly to dryneſs digeſt it in very dilute muriatic acid, which will take up every thing but the ſulphat of *Lead.*

e Add together the nitro-muriatic ſolutions, (*c*, *d*) and decompoſe the whole by carbonat of ſoda, then digeſt the precipitate thus obtained in cauſtic ammonia, by which the zinc and copper will be taken up.

f Saturate the preceding ammoniacal ſolution with muriatic acid, and then boil it, adding cauſtic ſoda as long as any precipitate falls down; this precipitate is brown oxyd of *Copper.*

g The ſoda ſolution, now containing only oxyd of zinc, is to be ſaturated with muriatic acid, decompoſed by carbonat of ſoda, and the precipitate thus procured, after ignition, is oxyd of *Zinc*.

h The reſidue inſoluble in ammonia (*e*) is to be abſtracted repeatedly with nitric acid, and then digeſted in cauſtic ſoda: what remains inſoluble is oxyd of *Iron*, with a ſlight contamination of arſenic.

i The preceding ſoda ſolution is to be ſaturated with nitric acid, and nitrat of lead is to be added till it ceaſes to produce a precipitate. This precipitate is *arſeniat* of lead.

k To the remaining fluid is firſt to be added ſulphat of ſoda, in order to get rid of any nitrat of lead that it would probably contain, and the filtered liquor being decompoſed by carbonated ammonia a precipitate will fall down, which, when well waſhed and ignited, is pure *alumine*.

A conſiderable difficulty however ſtill remains in eſtimating properly the relative proportions of Blende, even after the analyſis has been performed in the moſt careful manner. This ariſes from the uncertainty of the ſtate in which the zinc and ſulphur (which are the principal ingredients) exiſt in this ore. According to ſome chemiſts, pure blende, excluſive of all caſual admixtures, is a true ſulphuret of zinc, the latter being in the metallic ſtate. The reaſons adduced in favour of this opinion are, Firſt, that this is conformable to the compoſition of the other native metallic ſulphurets, ſuch as the different ſpecies of pyrites, and the ſulphurets of lead, antimony, ſilver, &c. Secondly, that if blende be digeſted in muriatic acid ſulphuretted hydrogen will be given out (as was firſt obſerved by Bergman) which gas can only proceed from the decompoſition of water by the metallic zinc, and the union of its hydrogen with part of the ſulphur, while in the act of being ſeparated from the zinc by the powerful affinity of the acid for this laſt.

On the other hand, however, it may be remarked that metallic zinc and ſulphur cannot be made to combine together by art, but that oxyd of zinc and ſulphur unite by fuſion, producing a yellowiſh compound not unlike blende. The tranſparency of this mineral is alſo a character in which it differs from the other proper metallic ſulphurets. It is true that ſulphuretted hydrogen is given out during its ſolution in muriatic acid, but this would alſo happen if the ſulphuretted hydrogen pre-exiſted in the ore. It is the opinion of Vauquelin that blende is a ſulphuretted oxyd, which often contains beſides ſulphuretted hydrogen, and this ſeems to be confirmed by the obſervation of Bergman[d] that *concentrated* ſulphuric acid ſeparates ſulphuretted hydrogen from blende; which cannot happen with a proper metallic ſulphuret. The deduction however from this fact is ſomewhat equivocal, for the proportion of ſulphuretted hydrogen by concentrated ſulphuric acid is greatly inferior to that produced by muriatic acid, and when it is conſidered that all blende affords by diſtillation a portion of water, is it not very poſſible that the hydrogen may be furniſhed by the decompoſition of this laſt? But the production of ſulphuretted hydrogen from it, by the agency of acids, by no means proves that the zinc muſt neceſſarily be in one of the forms above-mentioned; common liver or glaſs of antimony, which is decidedly a ſulphuretted ſub-oxyd, affords ſulphuretted hydrogen when digeſted with acids, and it appears highly probable, on taking into conſideration all the properties of blende, that this alſo is a ſulphuretted ſub-oxyd.

The ores of zinc cannot be aſſayed in the common method on account of the great volatility of this metal, they are therefore treated in one of the two following ways.

1. The ore, being firſt bruiſed, is to be very carefully ſeparated from any intermixed particles of galena and other impurities, and is then to be roaſted, care being taken, eſpecially in an aſſay of blende, that the whole of the ſulphur is driven off. The roaſted ore is now reduced to fine powder, together with half its weight of charcoal, and the mixture is put into an earthen retort, to the beak of which a tube or adopter is fixed dipping in water. After the retort with its contents has been expoſed for about three quarters of an hour to a high heat in a wind furnace, it is to be cooled gradually, and on breaking the veſſel the zinc will be found concreted in metallic drops in its neck.

2. The ore, after being prepared and mixed with charcoal, as above mentioned, is to be ſtratified in a crucible with its own weight of copper clippings; a perforated cover being luted on, the crucible is to be kept at a cherry red or low white heat for the beſt part of an hour, being then allowed to cool, its contents are taken out and waſhed, by which the globules of braſs are readily ſeparated from the lighter impurities. The exceſs of weight which the braſs has over the copper employed, indicates the quantity of zinc abſorbed from the ore.

§. 3. *Reduction of Ores.*

The ore, whether calamine or blende, after being raiſed from the mine, is firſt dreſſed, that is, it is broken to ſmall pieces, and the galena, pyrites, and other impurities are ſeparated as accurately as poſſible by hand; it is next calcined at a moderately red heat in a reverberatory furnace, by which the calamine is deprived of its carbonic acid, and the blende of the moſt part of its ſulphur. It is then waſhed, by which the lighter earthy parts are ſeparated from the metallic oxyd, which latter, being dried, is intimately mixed with about $\frac{1}{8}$ of its weight of charcoal by grinding the ingredients together in a mill, and is now ready to be ſmelted. The furnace in which the reduction is performed is a circular one not unlike that of a glaſs-houſe, in it are fixed ſix large earthen pots, about four feet high, and nearly of the ſame ſhape as oil jars: into the bottom of each pot is inſerted an iron tube that paſſes through the arched floor of the furnace, and dips in a veſſel of water placed beneath, while the other end of the tube riſes within the crucible to within a few inches of its top. Theſe crucibles are filled up to the level of the tube with the mixture of roaſted ore and charcoal, the cover of each is very accurately luted on, and the furnace is charged with fuel, by which an intenſe heat is kept up for ſeveral hours. The zinc, as it is reduced, aſcends to the top of the pot in the form of vapour, and there being prevented from eſcaping by the cloſely luted cover it deſcends through the central iron tube, whence it paſſes into the water, and is there condenſed in ſmall drops. Theſe globules are afterwards melted and caſt into ingots, in which ſtate they are brought to market.

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[d] Bergm. Opuſc. ii. p. 338.

Common zinc generally contains a little lead, copper, arſenic, iron, manganeſe, and probably plumbago, which often conſiderably impair the quality of the alloys into which it enters. In order to get rid, in part at leaſt, of theſe impurities, the common practice is to melt the zinc in a crucible, and then to ſtir into it, by means of a ſtick or earthen rod, a mixture of ſulphur and fat: the latter of theſe preſerves the zinc from oxydation, while the former, uniting with all the metals preſent, except the zinc, converts them into ſulphurets, which riſing to the top form a ſcoria that may be ſkimmed off: this is to be repeated as long as any ſcoria makes its appearance. M. Prouſt objects to this method as completely ineffectual and propoſes another, which is ſimply rediſtilling the zinc in an earthen retort; after the metal has paſſed over there remains behind a mixed maſs of oxyds and other impurities. But it is not very obvious how either the arſenic or lead can be thus got rid of, nor does it by any means appear that the old method is ſo very nugatory. It would probably be an improvement firſt to heat the zinc nearly to melting, in which ſtate it is very eaſily pulverizable, and having thus reduced it to fine powder, to mix it with about $\frac{1}{5}$ of its weight of ſulphur and a little pitch, then to charge an earthen retort with the mixture, to keep it for ſome time at a temperature not exceeding that of melted lead, and then to raiſe it by degrees till the zinc begins to be volatilized: the contents of the retort being now allowed to cool gradually, the purified zinc would be found at the bottom, covered by a ſcoria of ſulphuret.

If however the zinc is required of extreme purity, take the common ſulphat of zinc (white vitriol of the ſhops) diſſolve it in hot water, and add a little ſulphuric acid and granulated zinc, by this means the copper, arſenic, and the principal part of the iron will be precipitated. When the acid is ſaturated pour off the clear liquor, and evaporate it to dryneſs; moiſten the white ſalt thus procured with a little nitric acid, and heat it nearly to redneſs in a crucible; by this the reſidue of the iron and manganeſe will be reduced to the ſtate of inſoluble oxyd, and warm water will take up only the pure ſulphat of zinc. This is to be decompoſed by carbonat of ammonia, and the white precipitate thus obtained, after being waſhed and calcined, is to be mixed with about $\frac{1}{6}$ of charcoal, and reduced by diſtillation in the uſual way.

§. 4. *Phyſical and Chemical Properties.*

The colour of zinc is bluiſh-white with a high metallic luſtre; its texture is between hackly and foliated, that is to ſay, the plates of which it conſiſts inſtead of being ſmooth like thoſe of biſmuth or antimony, are covered with a multitude of ſmall points which render it peculiarly harſh to the touch. In thin plates it may be broken without difficulty, but in doing ſo a kind of reſiſtance is perceived, as if the facets of which it is compoſed adhered to each other not merely by the appoſition of their ſurfaces, but by the mutual penetration of thoſe little points with which, when ſeparated, they appear to be covered. The larger ingots cannot be broken but by means of iron wedges. Zinc at the common temperature poſſeſſes a moderate degree of ductility, and may be laminated by paſſing through rollers into plates of conſiderable thinneſs and elaſticity. With care it may be drawn into wire, the tenacity of which, according to Muſchenbroeck, is equal to about 26 lbs. upon $\frac{1}{10}$ of an inch in diameter. If, however, zinc is hammered at about the temperature of 300° F. its malleability is greatly increaſed; it will now bear to be bent backwards and forwards ſeveral times before it breaks; its fracture is fibrous and ſteel grained; it may be reduced into thin leaves by lamination, and may be drawn into wire not exceeding $\frac{1}{200}$ of an inch in thickneſs, and poſſeſſing nearly the tenacity of ſilver.[b] The hardneſs of zinc is ſomewhat inferior to that of copper: its ſpecific gravity varies from 6.8 to about 7.1; by hammering it is increaſed to 7.19. It yields eaſily to the file, but in a very ſhort time entirely clogs up the teeth of this inſtrument, rendering it quite ſmooth. By friction, or even when kept in a moiſt warm hand for a ſhort time, it gives out a very ſenſible metallic odour, ſomewhat reſembling that of iron. When heated to 400° Fahr. and upwards, it becomes perfectly brittle, and in this ſtate may be pulverized without difficulty in a heated mortar. At about 700° Fahr. it melts, and in a full red heat is volatilized. It cryſtallizes with difficulty into tetrahedral or compreſſed hexahedral priſms.

The action of air upon zinc at the common temperature is very ſlight; it acquires a very thin ſuperficial coating of grey oxyd, which adheres to the metal and prevents any further change. But if the zinc is melted it ſoon becomes covered with a pellicle of grey oxyd, and this being removed as faſt as it forms, the whole maſs of metal is in no very long time entirely oxydated. If the grey oxyd thus formed is ſtill further calcined at a red heat, it acquires a greeniſh-yellow colour, and increaſes in weight: by a white heat it runs into a compact yellow glaſs.

If zinc inſtead of being merely melted is ignited, it takes fire and burns rapidly, with an intenſe bluiſh-white flame of great brilliancy: as the combuſtion goes on, the metal is converted to a yellowiſh-white flocculent oxyd, ſo light as to be thrown up into the air by the force of combuſtion, a peculiar odour which has been likened to that of arſenic being given out. This ſublimed oxyd is commonly known by the name of *Flowers of Zinc*, and in the writings of the older chemiſts by thoſe of *Nihil album*, *Pompholix*, *Philoſophical Wool*, &c. If this oxyd as ſoon as prepared is put into a dark place, it will be perceived to emit a bluiſh phoſphoric light for the ſpace of an hour or more. Another phenomenon which has probably ſome relation to the above is, that, if a filter be filled with flowers of zinc, and water repeatedly paſſed through them, they will appear ſuperficially of a dazzling white, and internally of a pure ſky-blue, which laſt however is replaced by the common yellowiſh tinge in proportion as it becomes dry. The flowers of zinc like the other oxyd are reducible by an intenſe heat into a yellowiſh glaſs.

The compoſition of the oxyds of zinc is by no means yet aſcertained with the deſired preciſion, we ſhall therefore ſtate the reſults of all the experiments that have been made on this ſubject, with ſuch obſervations as may ſuggeſt themſelves.

1. According to Bergman,[c] 100 parts of zinc, after being diſſolved in dilute ſulphuric acid and precipitated by cauſtic ſoda, afforded 161 of oxyd dried at the temperature of boiling water; therefore 100 parts of oxyd are compoſed of 62 zinc and 38 oxygen. But the oxyd dried at this low temperature muſt neceſſarily retain a conſiderable portion of water; indeed it is by no means improbable that it would actually be in the ſtate of hydrat, which, according to Mr. Smithſon, is compoſed of 75 oxyd and 25 water. If the neceſſary correction be made upon this ſuppoſition, 100 parts of oxyd will conſiſt of 83.3 zinc, and 16.7 oxygen.

2. According to Vauquelin,[d] (but from what particular experiments we are not informed) 100 parts of oxyd of zinc produced by calcination of the artificial carbonat, are compoſed of 69 of zinc and 31 of oxygen.

3. According to Clement and Deſormes,[e] 14.36 parts of zinc heated red-hot in a coated glaſs tube, with a ſtream of air paſſing through it, afford 17.48 parts of a white oxyd, the compoſition of which therefore *per cent.* is 82.15 zinc, and 17.85 oxygen.

The ſame chemiſts found that 30 grammes of ſublimed oxyd of zinc, by diſtillation with charcoal at a high heat were reduced to 21.82 grammes of metallic zinc, according to which 100 parts of ſublimed oxyd conſiſt of 72.4 zinc, and 27.6 oxygen. In this however the amount of zinc is very probably under rated, as ſeveral minute particles might remain unperceived in the charcoal.

It appears from another experiment of the above chemiſts, that the ſublimed oxyd when expoſed to a forge heat for a quarter of an hour loſes about 7 *per cent.* and at the ſame time acquires a dull yellow colour; hence the compoſition of this ſub-oxyd is 88 of zinc to 12 of oxygen.

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[b] Phil. Mag, xxiii. p. 282.

[c] Opuſcula, ii. p. 392.

[d] An. de Ch. xxviii. p. 47.

[e] Ib. xxxix p. 32.

4. Some experiments of Prouſt[f] on the ſame ſubject deſerve to be cited. According to this able chemiſt, 100 parts of zinc, by ſolution in nitric acid, and ſubſequent ignition afford 125 of yellowiſh oxyd. Alſo 100 parts of zinc when diſſolved in nitric acid and precipitated by carbonat of potaſh afford 180 of dry carbonat, which by calcination is reduced to 125 of mere oxyd. Hence according to both theſe experiments, oxyd of zinc is compoſed of 80 zinc and 20 oxygen.

5. According to Morveau the greeniſh oxyd formed by calcining the grey oxyd is compoſed of 85 *per cent.* zinc and 15 oxygen; and

6. According to Wenzel the moſt highly calcined oxyd of zinc conſiſts of 80 zinc and 20 oxygen, in which he perfectly agrees with Prouſt.

What concluſion can be drawn from theſe various reſults except the neceſſity of freſh experiments?

The mutual action of zinc and water is very conſiderable. If pulverized zinc be moiſtened with this fluid at the common temperature, the mixture in the ſpace of a few hours becomes black, increaſes in bulk, diſcharges hydrogen gas with a viſible effervеſcence, and at length is converted into a greyiſh-white oxyd. At a high heat the decompoſition of the water is much more rapid, as we learn from an experiment of Dr. Prieſtley's; this philoſopher having incloſed ſome zinc in a glazed earthen tube heated it red, and then paſſed ſteam over it; a large quantity of hydrogen was produced, and the zinc was converted into a dark coloured ſemi-tranſparent glaſs.

The action of the alkalies is very ſtriking, and was firſt obſerved with accuracy by De Laſſone[g]. If filings of this metal are immerſed in ſtrong and perfectly cauſtic liquid ammonia and a gentle heat applied, the mixture ſoon becomes turbid and milky, a copious effervеſcence, probably of hydrogen gas, takes place, the odour of which is ammoniacal and alliaceous, the zinc is by degrees diſſolved, and the ſolution, during the effervеſcence, becomes of a deep black colour. The ſolution being completed, a little black powder falls to the bottom, and the liquor after filtration is perfectly clear and of a yellow colour. If the zinc employed is in the ſtate of ſublimed oxyd inſtead of metallic filings, the liquor becomes ſenſibly hot, no gas is given out, and the ſolution is completed in a conſiderably ſhorter time than was required in the former caſe. Ammoniuret of zinc concretes by cooling and evaporation into feathered cryſtals, which are permanent in the air. If the ammonia is ſaturated with zinc the ſolution is in part decompoſed by water, a white oxyd being precipitated; this however may be prevented by pouring in a little ammonia previous to the addition of water. No viſible change is produced by the addition of cauſtic fixed alkali, but all the acids decompoſe it, throwing down the metallic oxyd: with tincture of galls a deep grey precipitate is produced: if a plate of copper is immerſed in the ſolution the zinc is in part precipitated and the copper is diſſolved, tinging the ammonia of a blue purple colour.

The cauſtic fixed alkalies act upon metallic zinc in nearly the ſame manner as ammonia does, but according to De Laſſone they are incapable of diſſolving the ſublimed oxyd. This is remarkable, for it is certain from the experiments of Vauquelin and others that the oxyd precipitated from the ſalts of zinc is perfecty ſoluble in either potaſh or ſoda.

Owing to the powerful affinity of zinc for oxygen it combines with the acids with great readineſs, forming a numerons claſs of ſalts, many of which are of importance.

Concentrated ſulphuric acid when aſſiſted by heat diſſolves zinc either in the metallic ſtate, or in that of. oxyd, ſulphurous acid gas being given out in the former caſe. If the acid is diluted with water it acts rapidly on zinc at the common temperature, an abundance of hydrogen gas being given out. The ſolution when completed, and filtered to ſeparate a ſmall portion of inſoluble black matter, affords, by evaporation and cooling, *ſulphat of zinc* in the form of compreſſed tetrahedral or hexahedral priſms terminated by tetrahedral pyramids. This ſalt if free from iron (which however it ſeldom is without particular precautions) is perfectly colourleſs and tranſparent, it is moderately hard, and has a diſagreeably ſtyptic metallic flavour which remains long on the palate. Its ſp. gr. is 1.912. It is ſoluble in about 2½ parts of water at 60°, and in a much ſmaller proportion of boiling water. It effloreſces by expoſure to the air. In a dry heat it firſt melts in its water of cryſtallization, and is reduced to an opake maſs, afterwards by ſtrong ignition it parts with moſt of its acid in the form of ſulphurous acid gas. It is decompoſed in the moiſt way, with precipitation of its oxyd by all the alkalies, either cauſtic or carbonated, and by all the alkaline earths. The proportion of its component parts is very variouſly ſtated. According to Bergman[h] 100 parts of the cryſtallized ſalt loſe 40 by gentle calcination, which are therefore water; the reſidue after being kept white hot for three hours was reduced to 20 parts of a greeniſh-grey colour which was oxyd of zinc, the acid having been driven off. From theſe data ſulphat of zinc conſiſts of

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[f] An. de Ch. xxxv. p. 53.

[g] Mem. Sci. 1775.

20.	Oxyd of zinc
40	Sulphuric acid
40	Water
100	

But according to Mr. Kirwan[i] 100 parts of ſulphat of zinc by a heat of 376° loſe 39 which are water, and a ſimilar quantity of the ſame ſalt afforded with muriat of barytes 61.24 of ignited ſulphat of barytes. But the compoſition of ſulphat of barytes is variouſly ſtated. Klaproth, Black and others reckoning the amount of acid in this ſalt to be 33.33 *per cent.* whereas Mr. Chenevix eſtimates it at no more than 23.5. Hence the compoſition of ſulphat of zinc as found by Mr. Kirwan's analyſis may be reckoned at

39.		Water
20.4.	or 14.3	Sulphuric acid
40.6.	or 46.7	Oxyd of zinc

Mr. Smithſon[k] again, from ſome ſimple and apparently accurate analyſes reckons the component parts of dry ſulphat of zinc to be

50	Sulphuric acid
50	Oxyd
100	

The ſalt called in commerce *White vitriol* is an impure ſulphat of zinc of a bluiſh-white colour with ochery ſtains externally; it has a granular cryſtalline texture like loaf ſugar, and is in irregular lumps and maſſes. It is prepared largely at Rammelſberg and elſewhere in Germany by roaſting blende and then expoſing it to the air; the ſulphats of zinc, lead, iron and copper that are thus formed, are ſeparated from the earthy parts by lixiviation, and the liquor being boiled down till a ſtrong ſaline pellicle forms on its ſurface is let out into cryſtallizing vats where it concretes into hard granular maſſes. The Engliſh white vitriol is prepared for the moſt part by direct ſolution of metallic zinc in ſulphuric acid, and is therefore purer than the foreign, though it ſtill contains a very notable quantity of iron. Both kinds may be conſiderably, though not entirely, purified by ſolution in water, and then abandoning the liquor to ſpontaneous evaporation in an open veſſel containing ſome granulated zinc: the ſulphat of lead will ſubſide to the bottom, and other foreign ſulphats will be decompoſed by the metallic zinc. The ſaline maſs when dry is to be lixiviated with cold water and the clear filtered ſolution, after due evaporation, will afford regular cryſtals of ſulphated zinc.

Sulphite of zinc is prepared by putting ſome oxyd of zinc and water into a Woulfe bottle, and throwing in ſulphurous acid gas till the oxyd is diſſolved. The ſalt thus formed cryſtallizes by gentle evaporation. It has a ſtyptic ſulphureous flavour: it is eaſily ſoluble in water, but not at all ſo in alcohol: it is decompoſed by the other acids with efferveſcence owing to the eſcape of ſulphurous acid gas; it forms white precipitates with the alkalies which are entirely re-ſoluble in cold dilute ſulphuric acid: by expoſure to the air it is ſoon converted into the ſulphat.

If ſulphurous acid is digeſted upon metallic zinc inſtead of the oxyd, an immediate and rapid action takes place between them; much heat is diſengaged, ſulphuretted hydrogen gas is produced, the fluid becomes of a turbid brown or yellow colour, but grows clear in proportion as the ſaturation advances. The fluid thus produced has a remarkable pungent ſtyptic and ſulphureous flavour: when gently evaporated it becomes thick like ſyrup, and then depoſits acicular tetrahedral priſms terminated by very acute tetrahedral pyramids; theſe when expoſed to the air become effloreſcent, and are ſlowly decompoſed into a mixture of ſulphat of zinc and ſulphur. Before the blow-pipe this ſalt gives out a vivid light like zinc in combuſtion, and throws out on every ſide arboreſcent and tubercular ramifications. The ſulphuric and muriatic acids decompoſe it with efferveſcence, ſulphurous acid gas being given out, and a yellowiſh-white powder being precipitated. Nitric acid alſo ſets at liberty ſulphurous acid, and throws down a flocculent ductile and adheſive precipitate which is ſulphur. When diſtilled *per ſe* in a retort it affords water, ſulphurous and ſulphuric acids, ſublimed ſulphur, and there remains behind oxyd of zinc with a little ſulphat. By digeſtion with alcohol it is decompoſed into two portions, of which one is inſoluble and the other readily ſoluble in this fluid. The former is ſulphite of zinc already mentioned; the latter is *Sulphuretted ſulphite of zinc;* it gives out on the addition of ſulphuric acid both ſulphur and ſulphurous acid, and to this are obviouſly owing all thoſe properties of the compound ſalt by which it is diſtinguiſhed from the pure ſulphite.

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[h] Opuſcul ii p. 328. [i] On real Acid, p. 69. [k] Phil. Tranſ. 1803. p. 23. [l] Fourcr. Syſt. des Connaiſſ. v. p. 380.

Nitric acid, moderately ſtrong, is ſaid to be capable of inflaming zinc filings, and even when much diluted acts on this metal with great violence, and with a copious diſengagement of nitrous gas and nitrous oxyd. The ſolution is generally of a pale greeniſh yellow colour, and is highly cauſtic: by evaporation and cooling it depoſits *Nitrat of zinc,* in compreſſed, ſtriated, tetrahedral priſms, terminated by tetrahedral pyramids. The ſpecific gravity of this ſalt is 2.09. It abſorbs moiſture from the air, and deliquiates; it is readily ſoluble both in water and alcohol. When laid on hot coals it melts and detonates rather feebly, giving out a faint reddiſh flame; when heated *per ſe* in an earthen crucible it is decompoſed, giving out nitrous and oxygen gaſſes, and the metal remains behind in the ſtate of yellowiſh oxyd.

Muriatic acid acts with much rapidity on zinc, hydrogen gas of very conſiderable purity being given out. The ſolution is clear and colourleſs: by evaporation and cooling it gelatinizes, but cannot be made to cryſtallize. When diſtilled, there firſt ariſes a little ſtrong and fuming muriatic acid, and then the *muriat of zinc* itſelf paſſes over in a half ſolid conſiſtence, on which account it is often called *butter of zinc.* This ſublimed muriat is of an opake white colour, and conſiſts of minute priſmatic cryſtals. It is fuſible by a gentle heat, abſorbs moiſture from the air, and aſſumes a gelatinous conſiſtence; it is not decompoſable by mere water, and is very ſoluble both in this fluid and in alcohol: the alkalies decompoſe it, throwing down a beautifully white oxyd.

Oxymuriatic acid gas inflames filings of zinc that are thrown into it, and the reſult is a muriat of zinc not differing from the preceding.

Liquid phoſphoric acid attacks zinc with efferveſcence, hydrogen gas being given out: the *phoſphat of zinc* thus produced forms a white inſoluble powder. This ſalt may alſo be procured by adding to the ſulphat, nitrat, or muriat of zinc, any of the neutral phoſphats.

Water impregnated with carbonic acid acts readily on either metallic zinc or its oxyds. The ſolution by expoſure to the air becomes covered with an irideſcent pellicle of oxyd. The moſt ready way however of obtaining it is by the decompoſition of the ſulphat, or almoſt any of the other ſalts, by means of a carbonated alkali; a denſe white precipitate is thus formed, which, when well waſhed and dried, is pure *Carbonat of zinc.* According to Bergman, 100 parts of metallic zinc, when diſſolved in an acid, and precipitated by carbonated ſoda, afford 193 parts of carbonat; but Bergman's precipitates were dried only at 212°, and therefore probably retained a conſiderable portion of water. According to Prouſt,[m] 100 parts of zinc afford by ſolution in nitric acid and precipitation by carbonated potaſh, 180 parts of dried carbonat; in which reſult the experiments of Dizé and of Hecht, exactly coincide: theſe 180 parts are reduced by calcination to 125 of mere oxyd, hence the component parts of this ſalt when thoroughly dried, are

55	Zinc
14	Oxygen
31	Carbonic acid
100	

The fluoric and boracic acids act upon zinc, the former rapidly, the latter with difficulty, but the properties of theſe ſalts have not been examined.

If zinc filings are digeſted in diſtilled vinegar, they diſſolve in this fluid with efferveſcence, and the reſult is *acetat of zinc;* according to De Laſſone, 12 ounces of vinegar take up only 2 drams of zinc; if however radical vinegar or acetic acid be employed, the above quantity of metal will be taken up by $\frac{3}{4}$ of an ounce of acid. Flowers of zinc are alſo ſoluble with eaſe in acetic acid, a conſiderable degree of heat being excited during the proceſs. The taſte of this ſalt is bitter and metallic. It cryſtallizes in thin and ſhining hexagonal and rhomboidal plates: when heated *per ſe* in a retort a part ſublimes with little alteration, except that it is whiter than before. When laid on hot coals it burns with a blue flame. It is readily ſoluble in water and is decompoſable by the alkalies, by the mineral acids, and by all thoſe that form with zinc an inſoluble ſalt.

In conſequence of the medical application of acetat of zinc, the following facts may be of uſe to the practitioner. The ſpecific gravity of a ſaturated ſolution of acetat of zinc made by digeſting the cryſtallized ſalt in diſtilled vinegar, is = 1.055. Of this ſolution 900 grains contain 53 grains of dry, or 82.6 grains of cryſtallized acetat. One ounce by meaſure of the ſolution, weighs 506 grains, and contains 29.8 grains of dry, or 46.5 grains of cryſtallized ſalt.

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[m] An. de Chim. xxxv. p. 53.

The ſuccinic and benzoic acids form cryſtallizable ſalts with zinc, the properties of which have not yet been examined.

Oxalic acid diſſolves zinc with conſiderable effervefcence, and a white powder ſubſides, which is *Oxalat of zinc*. It may alſo be prepared by adding oxalic acid to the ſulphat, muriat, or nitrat of zinc. It is very ſparingly ſoluble in water, unleſs an exceſs of acid is preſent; it contains, according to Bergman, 75 *per cent.* of metal.

Citric acid in like manner diſſolves zinc with effervefcence, and minute cryſtalline grains are depoſited of *Citrat of zinc:* they have a ſtyptic and metallic taſte, are little ſoluble in water, and conſiſt, according to Vauquelin, of

50 Citric acid
50 Oxyd of zinc

100.

The ſalts formed by the other vegetable acids and zinc are very little known.

There are two triple ſalts of zinc; the one formed by digeſting filings of the metal in muriat of ammonia, the other by employing a ſolution of acidulous tartrite of potaſh (cream of tartar). Neither of theſe ſalts is cryſtallizable, nor are they decompoſed by the pure or carbonated alkalies.

The neutral and earthy ſalts are many of them decompoſable by zinc. Nitre and the other ſalts belonging to that genus detonate rapidly when heated with zinc. The alkaline ſulphats are converted into ſulphurets; and muriat of ammonia is decompoſed, ammoniacal gas being given out, and the acid combining with the oxyd of zinc.

Very little affinity appears to exiſt between zinc and ſulphur. As long as the former retains its metallic ſtate it cannot be made to combine with ſulphur by fuſion or in any other way. If zinc filings and flowers of ſulphur be made into a paſte with water, a decompoſition of this latter will take place, the metal will be oxydized, hydrogen gas will be given out, but the reſidual maſs will be a mere mixture of ſulphur and oxyd of zinc. A mixture of flowers of zinc and ſulphur combine by fuſion into a yellowiſh-brown maſs, which has been compared to blende. The alkaline ſulphurets when melted with oxyd of zinc and afterwards diſſolved in water, let go the greateſt part of the oxyd unaltered, they retain however a very ſmall portion. Water ſaturated with ſulphuretted hydrogen decompoſes after ſome time the ſalts of zinc, forming a yellow precipitate, which is probably a hydroſulphuret. Prouſt propoſes the uſe of this re-agent to purify zinc from copper and iron: the mixture being diſſolved in dilute nitric acid and duly neutralized, the hepatic water is to be carefully added till it ceaſes to produce a black precipitate; this is hydroſulphuret of copper, and may readily be ſeparated by filtration; to the clear liquor now add more of the hepatic water as long as any yellow precipitate falls down; this is the zinc: the iron remains in the ſolution.

Hydrogen appears capable of taking up a minute portion of zinc when it is produced by the rapid action of dilute ſulphuric acid on this metal: this hydrogen burns with a ſomewhat brighter flame than common hydrogen.

Zinc combines readily with phoſphorus, as Pelletier has ſhown, by adding to zinc, when in fuſion and covered with oil to prevent oxydation, a few pieces of phoſphorus. The *phoſphuret of zinc* thus produced is of a whitiſh colour and a metallic luſtre not unlike lead. It is ſomewhat malleable, exhales a phoſphoric odour by friction, and in a high heat burns like common zinc. Phoſphorus alſo combines with the oxyd of zinc: if a mixture conſiſting of 6 parts oxyd of zinc, 6 parts vitreous phoſphoric acid, and 1 part of charcoal powder, is ſtrongly heated in an earthen retort, a ſilvery-white vitreous matter is ſublimed, which, according to Pelletier, is phoſphorized oxyd of zinc.

Zinc combines with many of the other metals, forming alloys, the greater number of which have been already deſcribed.

Zinc and antimony unite by fuſion, forming a compact homogeneous brittle maſs, of an aſh-grey colour, and of leſs denſity than the mean of its ingredients.

Zinc with copper forms ſeveral important alloys, for an account of which ſee Brass and Copper, alloys of.

Zinc and Gold; ſee Gold, alloys of

Zinc unites with iron by fuſion, but not very eaſily on account of its volatility; the reſult is a hard ſomewhat malleable alloy of a white colour approaching to that of ſilver. Iron plate may alſo be covered with zinc in the ſame manner as it is with tin.

Zinc and Lead; ſee Lead, alloys of.

Zinc and tin combine by fuſion, forming a ductile alloy, harder than zinc and of a better colour.

Zinc and Mercury; ſee Mercury, alloys of.

Zinc forms with ſilver a bluiſh-white brittle alloy of a granular texture.

The uſes of zinc in its various forms are conſiderable. In its metallic ſtate it is employed by the Chineſe for coins, and has been propoſed in this country as a ſubſtitute for lead and tin in forming and lining various culinary veſſels: this however is extremely injudicious as zinc is remarkably ſoluble in all acids, and all its ſalts are violent emetics. In combination with copper it forms braſs and all the uſeful and ornamental gold coloured alloys. Its ſublimed oxyd has been uſed in oil painting as a ſubſtitute for white lead: it has not indeed the denſity of common white paint, and therefore one or two more coatings are required of the former than of the latter, but in return it is not liable to be blackened by ſulphureous vapours, and is entirely free from the deleterious effects of lead paint. Of the ſalts of zinc the ſulphat is largely uſed by varniſhers, &c. to make oil drying, and this together with the acetite is employed in medicine. In the laboratory the chief uſe of zinc is to procure hydrogen gas by the ſolution of it in the ſulphuric or muriatic acids.

ZIRCON. Jargon or Jargoon. Hyacinth.

Werner and his diſciples make two ſeparate ſpecies of the zircon or jargon, and hyacinth; but from the analyſes of Klaproth and Vauquelin, and the cryſtallographical reſearches of Hauy, it is evident that the two ſpecies ought to be conſolidated into one. The colour of this mineral is pale greyiſh-white, ſmoke-grey, and greeniſh-grey, leek-green and olive-brown, alſo pale wine-yellow, orange-yellow, bluiſh-red, blood-red, and reddiſh-brown. It occurs in ſmall rounded pieces and cryſtallized. Its primitive form is an octohedron with iſoſceles triangular faces: the angle formed at the common baſe of the pyramids is = 82°: 50′. It preſents alſo the following varieties of cryſtallization.

1. The rhomboidal dodecahedron.
2. The ſame as the preceding except that the ſides of the priſm are hexagons inſtead of rhombs.
3. Var. 2. with the common edges of the priſm and terminating pyramids truncated.
4. Var. 2. with the lateral edges of the priſm truncated.
5. A combination of the two preceding varieties, that is var. 2. with all the edges of the hexagonal faces truncated.
6. A ſtrait tetrahedral priſm terminated by tetrahedral pyramids.
7. The preceding with the ſolid angles at the baſe of the pyramids truncated.
8. Var. 6. with both the ſolid angles and common edges of the priſm, and terminating pyramids truncated.

The cryſtals are ſmall and very ſmall; externally they are ſmooth and ſhining; internally both the cryſtals and rounded pieces have a brightly ſhining luſtre, between adamantine and vitreous. The fracture is foliated paſſing into flat conchoidal: the fragments are indeterminate and ſharp edged. It varies from tranſlucent to tranſparent, and is doubly refracting in a high degree. It is hard enough to ſcratch quartz, though with difficulty. It is brittle and eaſily frangible. Sp. gr. 4.38—4.62.

It loſes its colour but is infuſible *per ſe* before the blow-pipe. The following are the analyſes that have been made of this mineral.

Jargon of Ceylon. Klaproth	*Hyacinth of Ceylon.* Klapr.	*Do.* Vauquelin	*Hyacinth of Expailly.* Vauquel.	
68.	70.	64.5	66.	Zircon
31.5	25.	32.	31.	Silex
0.5	0.5	2.	2.	Oxyd of Iron
100.	95.5	98.5	99.	

It occurs in the beds of rivers in Ceylon mixed with magnetic ſand, ruby, tourmaline, ſapphire, &c. alſo in the ſand of the brook Expailly in Auvergne; near Meronitz and Hohenſtein in Saxony; at Schelkowitz in Bohemia imbedded in trap; and at Friedrichſchwarn in Norway.

The yellow and ſmoke coloured varieties are called by the jewellers jargoons, and are not unfrequently paſſed off as diamonds: the orange-red varieties are called hyacinths. The commercial value both of one and the other is conſiderably inferior to that of the diamond and all the oriental gems.

ZIRCON (Earth).

This earth was firſt diſcovered by Klaproth[a], and its leading properties have ſince been carefully inveſtigated by Vauquelin[b]. It is obtained from the jargon or hyacinth (ſee the preceding article) by the following proceſs. The mineral being very accurately pulverized is to be mixed with ſix times its weight of perfectly cauſtic potaſh diſſolved in a little water. The maſs being evaporated to dryneſs in a ſilver crucible is to be kept at a low red heat for two hours: after this being allowed to cool it will be found ſtrongly adherent to the crucible, and muſt accordingly be covered with 10 or 12 times its weight of water, to which muſt then be added a ſufficiency of muriatic acid in order to ſuperſaturate the alkali. By a gentle digeſtion the whole of the maſs will be diſſolved, and the clear ſolution is to be evaporated ſlowly to dryneſs, ſtirring it about all the time to facilitate the ſeparation of the ſilex. The reſidue of the evaporation is now to be digeſted with a moderate quantity of water ſlightly acidulated by muriatic acid, which will take up the zircon and oxyd of iron, leaving the ſilex behind. This evaporation and re-ſolution in very dilute muriatic acid is to be repeated two or three times that every particle of ſilex may be ſeparated. To the muriatic ſolution is now to be added carbonat of ammonia, which will at firſt occaſion an abundant precipitate, but by adding an exceſs of the alkali the whole of the zircon will be re-diſſolved and the oxyd of iron will fall to the bottom. The clear filtered liquor is to be boiled for two or three hours, by which the exceſs of ammonia will be driven off, and the zircon will be depoſited in the ſtate of carbonat, and in the form of a white powder. This powder being waſhed and properly dried is afterwards to be calcined, by which about 43 *per cent.* of water and carbonic acid will be driven off, the remainder being pure zircon.

Calcined zircon is of a white colour, is rough to the touch, is inſipid and inſoluble in water. Its ſp. gr. is $= 4.3$. After being expoſed to an intenſe heat in a charcoal crucible it acquires a grey colour, a vitreous fracture, and is hard enough to give fire with ſteel. When precipitated by cauſtic alkali from its acid ſolutions it retains about $\frac{1}{4}$ of its weight of water, in conſequence of which, after drying in the air, it acquires the ſemi-tranſparence of horn, a yellow colour, and a conchoidal vitreous fracture. Sulphuric acid combines with zircon, forming an inſipid pulverulent ſalt, inſoluble in water, but readily decompoſable by heat, and even by long boiling in water. If this inſoluble ſulphat is digeſted in dilute ſulphuric acid it diſſolves, and by cautious evaporation may be brought to cryſtallize in needles: in this ſtate it is decompoſable by water, the exceſs of acid being abſtracted. The alkalies and alkaline earths decompoſe ſulphat of zircon, but the nitric and muriatic acids do not, though they diſſolve it readily. When heated in a retort with charcoal its acid is decompoſed, and by digeſting the ſulphuret thus formed in water it diſſolves, and the ſolution, by evaporation, affords colourleſs tranſparent cryſtals; their flavour is ſtrongly ſulphureous, but their other properties have not been aſcertained.

Nitric acid combines eaſily with zircon, eſpecially if this latter is moiſt and recently precipitated. This ſalt has always an exceſs of acid: it is not cryſtallizable but is reduced by evaporation to a viſcid gummy conſiſtence: to the taſte it is ſtyptic and aſtringent. It is decompoſed by ſulphuric acid, an inſoluble ſulphat being precipitated. Gallic acid occaſions in it a white precipitate, as alſo does hydro-ſulphuretted water and hydro-ſulphuret of ammonia.

Muriatic acid readily takes up zircon from the carbonat, but does not touch this earth after it has been calcined. It is ſoluble in water and alcohol, and by evaporation may be obtained in needle-ſhaped cryſtals. It is decompoſed by the ſame ſubſtances as the nitrat, and affords white flocculent precipitates with the phoſphoric, nitric, oxalic, and ſaccholactic acids.

Zircon is inſoluble in the moiſt way by the fixed alkalies either cauſtic or carbonated, but is taken up (as we have already mentioned) by carbonated ammonia.

When mixed with ſilex and alumine it is fuſible by a high heat into a white porcellanous maſs.

In its affinities for the acids it is decidedly inferior to the alkalies, the alkaline earths, and even to alumine.

Neither the earth nor its ſalts are made any uſe of.

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[a] Analyt. Eſſ. I. p. 175.

[b] Journ. des Mines, No. 25. p. 97.

ADDENDA.

CERIUM[a].

The ſubſtance called cerium by Hiſenger and Berzelius, two Swediſh chemiſts, and ochroïtes by Klaproth, is an earthy powder of a white, yellowiſh, or reddiſh-brown colour, and is conſidered by the former, with whom Vauquelin alſo coincides, as the oxyd of a new metal, while it is regarded by Klaproth as an earth, which, like yttria, holds a ſort of middle rank between the proper earths and metallic oxyds. Upon the whole we incline to the opinion of Vauquelin, and ſhall therefore in the following article conſider cerium as a metallic ſubſtance.

§ 1. *Ores.*

Sp. 1. Cerite. *Ochroïte* of Klaproth. *Reddiſh Tungſten* of Scheele. *Falſe Tungſten* of Elhuyars.

Its colour is between roſe and fleſh-red, reddiſh-brown and clove-brown; it occurs maſſive or diſſeminated. Its fracture is compact ſplintery. Internally it is ſhining. It varies from ſemi-tranſparent to opake. It ſcratches glaſs, and gives fire with difficulty when ſtruck againſt the ſteel. It is brittle and eaſily frangible. Sp. gr. 4.53—4.66.

Before the blow-pipe it is infuſible, but becomes friable, and acquires a brown colour according to Klaproth, but a yellow one according to Vauquelin. It is very ſparingly ſoluble in glaſs of borax.

Two varieties appear to have been analyſed: that by Klaproth was opake, and became brown by calcination; that by Vauquelin was ſemi-tranſparent and became yellow by calcination. The reſults are as follow:

Klapr.		Vauq.	
54.5	—	63.	Oxyd of Cerium
34.	—	17.5	Silex
4.	—	2.	Oxyd of Iron
0.	—	4.	Lime
5.	—	12.	Water
97.5		98.5	

It occurs at Baſtnaës, near Riddarhyttan, in Sweden, in gneiſs, accompanied by copper pyrites, biſmuth, and molybdena, hornblende, and actynolite.

§. *Analyſis.*

The analyſis of cerite is upon the whole beſt conducted in the following way.

a. Having minutely pulverized the ore, weigh it, then ignite it and weigh it again; the difference may be ſet down as the amount of *water*.

b. Digeſt the calcined ore in repeated portions of nitro-muriatic acid, and when nothing further is taken up fuſe the reſidue with cauſtic potaſh; then diſſolve out the maſs by muriatic acid, evaporate to dryneſs, and digeſt again in very dilute muriatic acid; the inſoluble reſidue is *Silex*.

c. Add together the muriatic and nitro-muriatic ſolutions, and decompoſe the whole at a boiling heat by ſaturated carbonat of potaſh. Rediſſolve the whole in as little muriatic acid as poſſible, heat the ſolution to drive off the laſt remains of carbonic acid, and add perfectly cauſtic ammonia till there is an evident exceſs. Separate the precipitate and add to the clear liquor as much muriatic acid as will ſaturate it, and then throw down from it the *Lime* in the ſtate of carbonat, by means of a mild alkali.

d. The ammoniacal precipitate conſiſting of the oxyds of cerium and iron, is to be diſſolved in muriatic acid, and liquid hydroſulphuret of potaſh is to be dropped in till the precipitate, which at firſt will be greeniſh, becomes white. The clear liquor being ſeparated and treated with carbonat of potaſh, affords a white precipitate, which is carbonat of cerium.

e. The greeniſh precipitate is to be diſſolved in as little muriatic acid as poſſible, and the ſolution being neutralized by an alkali to the point of precipitation, ſulphat of ſoda is to be added, which will throw down a ſulphat of cerium. The reſidual fluid being then decompoſed by ammonia depoſits oxyd of *Iron*.

f. The ſulphat of cerium (*e*) is now to be boiled with thrice its weight of carbonated ſoda, by which it will be converted into carbonat, which is to be diſſolved in dilute muriatic acid, and again precipitated by carbonat of potaſh or of ſoda.

g. The carbonats of cerium (*d* and *f*) are now to be calcined, by which the pure brown oxyd of *Cerium* will be obtained.

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[a] Nich. 8vo. viii p. 107. An. de Chim. liv. p. 28.

§ 3. *Phyſical and Chemical Properties.*

Pure cerium does not appear to have been yet obtained in the metallic form; in Klaproth's experiments the oxyd when incloſed in a charcoal crucible, and ſubjected to the intenſe heat of a porcelain furnace underwent no alteration. Vauquelin, however, by mixing the tartrite of cerium with a little oil, lamp-black and borax ſucceeded in obtaining a few minute globules of a metallic appearance, which appeared to be an alloy of cerium and iron.

The precipitate from any of the ſalts of cerium by means of a cauſtic alkali is the metal in its loweſt ſtate of oxydation. Its colour is white; by expoſure to the air it acquires a yellowiſh tinge in its progreſs towards the ſtate of perfect oxyd, but as it abſorbs at the ſame time carbonic acid it cannot by this proceſs arrive at its ultimate term of oxydation. When expoſed to the blow-pipe it paſſes rapidly into perfect oxyd, and acquires a reddiſh-brown colour, but undergoes no further change. When mixed in ſmall proportion with borax it forms a greeniſh-yellow tranſparent globule, which, by the exterior flame, becomes blood-red, and by long continuance of the interior flame becomes colourleſs.

The fixed alkalies when digeſted with heat on the brown calcined oxyd change its colour to white, and bring it to the loweſt term of oxydation, but do not diſſolve any of it. Ammonia has a ſimilar effect on the uncalcined oxyd.

Sulphuric acid, diluted with four times its weight of water and digeſted on the per-oxyd of cerium firſt communicates to it a brilliant cryſtalline appearance, and at length, if the acid is conſiderably in exceſs, forms a complete ſolution of it: this ſolution, by very gentle evaporation, depoſits minute orange coloured cryſtals, ſparingly ſoluble in water, and of a ſweet acidulous taſte. If the carbonat or ſub-oxyd of cerium, is employed, the reſult is a very pale roſe coloured ſolution which cryſtallizes without difficulty: this latter ſulphat contains no exceſs of acid, and has merely a ſaccharine taſte. The ſame ſalt may be produced by double affinity; if ſulphat of ſoda is added to the nitrat or muriat of cerium a cryſtalline precipitate falls down, which is the ſalt in queſtion.

Nitric acid, aſſiſted by heat, diſſolves eaſily either of the oxyds, forming a yellow ſolution, which cannot be made to cryſtallize; the ſalt however may be obtained by gentle evaporation. It has a ſomewhat pungent ſaccharine taſte; is ſoluble in twice its weight of alcohol, and when expoſed to heat it melts, is decompoſed, and a brick-red oxyd remains behind.

Muriatic acid when digeſted on the per-oxyd of cerium exhales an abundance of oxymuriatic acid gas; the oxyd is by degrees diſſolved, forming a pale roſe coloured ſolution, which, when evaporated to the conſiſtence of a thick ſyrup, depoſits a confuſed maſs of cryſtals. This muriat has a ſweetiſh flavour, is ſoluble in three or four times its weight of alcohol, and when decompoſed by dry diſtillation, there comes over oxymuriatic acid, and a white ſub-oxyd of cerium remains in the retort.

Any of the preceding ſalts are decompoſable by the alkaline carbonats, ſuccinats, phoſphats, tartrites and oxalats forming white precipitates, the properties of which have not yet been inveſtigated.

Neither tincture of galls nor hepatic water produce any decompoſition of the above ſalts of cerium, but the liquid alkaline hydro-ſulphurets throw down a yellowiſh-white precipitate; and pruſſiat of potaſh a milk-white one, provided no iron is preſent.

No uſe whatever has been made of cerium in any form.

SCHORL, (*omitted by miſtake in its proper place*). Tourmaline. Cockle *of the Corniſh miners*.

Werner divides this mineral into two ſub-ſpecies, one of which he calls the black and the other the electric ſchorl. But as both of them are electrical, and as the differences between them are very trivial, we have thought beſt to follow the example of Hauy, and conſider them as forming only one ſpecies.

The colour of this mineral is greyiſh-white; leek, olive, and piſtachia green; liver-brown, yellowiſh and reddiſh-brown; hyacinth-red, crimſon-red; violet-blue, ſky and indigo-blue; velvet-black. It occurs in maſs, diſſeminated, in rolled pieces and cryſtallized. Its primitive form is an obtuſe rhomboid, the larger plane angles of which meaſure 113° 34′ 41″. The actual forms that it preſents are the following.

1. A nine-ſided priſm, terminated at one extremity by ſix, and at the other by three facets. Of the ſix facets, three are hexagons, and three triangles.

2. A twelve-ſided priſm terminated at each extremity by the ſame number of facets as the preceding. Of the ſix facets, three are heptagons, and three trapeziums.

3. A nine-ſided priſm, terminated by the ſame number of facets as the preceding. Of

the ſix facets, three are heptagons, and three rhombs.

4. A nine-ſided priſm, terminated as above. Of the ſix facets, the three larger are hexagons, and the three ſmaller irregular heptagons.

5. A nine-ſided priſm, terminated at one extremity by ſeven, and at the other by three facets. Of the ſeven, ſix are alternately rhombs and parallelograms ſurrounding an equilateral triangle.

6. A nine-ſided priſm, terminated as the preceding. Of the ſeven faces, ſix are alternately triangles and pentagons ſurrounding a triangle.

7. A twelve-ſided priſm, with nine faces on each ſummit.

8. A nine-ſided priſm, with nine faces on one ſummit, and three on the other. Of the nine faces, three are rhomboidal, and form the terminating pyramid, the other ſix are formed by truncatures of the common baſe of the pyramid and priſm.

9. A nine-ſided priſm, one of the ſummits of which is unknown, the other is a pyramid compoſed of three lengthened hexagons with two trapeziums intervening between each.

10. A nine-ſided priſm, one of the ſummits of which is unknown; the other is compoſed of 15 faces, viz. three pentagons, three triangles, three rhombs, and ſix parallelograms.

11. A twelve-ſided priſm, one of the ſummits of which is unknown, the other is compoſed of 19 facets.

12. A twenty-four ſided priſm, one of the ſummits of which is unknown, the other is compoſed of ſix facets, alternately large and ſmall.

The priſms are generally long in proportion to their thickneſs, and longitudinally ſtriated. The internal luſtre is more or leſs ſhining, between vitreous and reſinous. The longitudinal fracture is conchoidal, paſſing in the black varieties to coarſe-grained uneven; the croſs fracture has a tendency to foliated. It varies from tranſlucent to opake. Its hardneſs is about equal to that of quartz. It is eaſily frangible. Sp. gr = 3.09—3.15.

Before the blow-pipe it is fuſible by itſelf, without much difficulty. By friction it exhibits the vitreous electricity at each extremity; by heating, one end exhibits the vitreous, and the other the reſinous electricity. The following are the principal analyſes that have been made of it.

Black S. in maſs.	D° Cryſtallized.	Tourmaline from Tyrol.	D° from Ceylon.	D° from Braſil.	Green D° from Braſil.
Gerhard		Bergman			Vauquelin
40.	38. Silex	40.	37.	34. Silex	40. Silex
25.	20. Alumine	42.	39.	50. Alumine	39. Alumine
15.	20. Lime	12.	15	11. Carb. Lime	3.84 Lime
18.	19. Iron and Manganeſe	6.	9.	5. Ox. Iron	12.5 Ox. Iron
					2. Ox. Manganeſe
98.	97.	100.	100.	100.	97.34

Schorl occurs in primitive rocks, eſpecially in gneiſs and granite, in micaceous and argillaceous ſchiſtus. It often is imbedded in quartz, but never, we believe in felſpar. The opake black varieties with a granular fracture are called ſchorl, the others are called tourmaline.

Tourmaline is found in Ceylon, Madagaſcar, Daouria, Ava, Braſil, Spain, Switzerland, Sweden, Norway, France, Scotland, and Saxony. Schorl is more abundant, in Europe at leaſt, than tourmaline is, and is found in moſt of the granitic and micaceous diſtricts.

Tourmaline is ſometimes cut into ring-ſtones, but its commercial value is very ſmall.

APPENDIX, No. 1.

DESCRIPTION OF THE CHEMICAL APPARATUS MOST FREQUENTLY USED FOR GENERAL PURPOSES, WITH REFERENCE TO THE PLATES.

ACID-HOLDER. Pl. I. Fig. 12—VI. 66. This is a ſmall glaſs phial, the mouth of which is cloſely fitted into and inverted over the neck of a retort or other veſſel, and is furniſhed with a glaſs ſtop-cock. Its uſe is to drop any acid or other liquor gradually into a retort or other veſſel in which any proceſs is going on, without admitting the external air or deranging any other part of the apparatus. The quantity of acid dropped in is regulated by the ſtop-cock.

As the common acid-holders (Fig. 12) have no communication with the external air, it is difficult entirely to regulate the fall of the acid, on which account we have given Mr. Pepys's improvement to it (Fig. 66) that has another glaſs ſtopper at the upper end, by opening which the dropping of the acid may be completely regulated.

ADOPTER. Pl. I. Fig. 3.

This is a hollow glaſs veſſel of the form of a ſpindle, the upper part of which *receives* the beak of a retort, and the lower part *enters* the neck of a receiver, as ſhewn in the plate referred to.

Its uſe is to increaſe the diſtance between the two, and thus to facilitate the condenſation of the heated vapour, which is often of importance where the vapour is not readily condenſible, and the receiver liable to be heated by the fire.

AIR-HOLDER. See Gazometer.

AIR-FURNACE. See Furnace.

ALEMBIC. See Distilling Apparatus.

ALUDEL. Pl. II. Fig. 36.

This is an old apparatus for ſublimation, conſiſting of any number of earthen pots of the form repreſented, the upper fitting into the lower, and the loweſt of all entering into a round crucible or any other convenient veſſel in which the ſubſtance to be ſublimed is heated. Aludels however are now almoſt entirely diſuſed, almoſt all ſublimations being performed only in two veſſels, viz. the lower one in which the material is heated, and the upper, which receives the ſublimate; it having been found that where aludels were employed, almoſt all the ſublimate that could be collected at all, was detained in the firſt veſſel; and another inconvenience of aludels is that the ſublimed matter if accidentally detached is very liable to fall down again into the crucible.

AREOMETER. See Specific Gravity.

ATHANOR. See Furnace.

BALLOON. Pl. II. Fig. 39. *c*.

This is ſimply a large glaſs globe with a plain neck of moderate length, and anſwers a variety of purpoſes.

BALNEUM. }
BATH. } A bath or balneum in chemiſtry is (like a common warm-bath) an intermede by which any body immerſed in it, totally or partially, may be heated more uniformly and moderately than from direct contact with the fire. The common balnea in chemiſtry are veſſels filled either with water or ſand and ſet immediately over the burning fuel.

The Common Water Bath cannot receive a greater heat than 212°, and it will not raiſe the temperature of any ſubſtance immerſed in it, quite ſo high. It is ſometimes attached to an alembic. (Pl. II. Fig. 34. *b.*)

It is particularly uſeful in evaporations of animal or vegetable matter, where the product would be altered and ſpoiled by a ſcorching heat, and in ſuch caſes an evaporating veſſel ſet in any iron pan full of water over a fire, will often anſwer every purpoſe, care being taken to ſupply water as it evaporates.

A greater heat is given by the *Sand-Bath* (Pl. I. Fig. 10—VIII. 82—X. & XI. Fig.

K. L.) which conſiſts of an iron pot ſunk into a furnace, and filled with ſand. It takes a longer time to heat than the water does, and the heat is much leſs uniform through the ſand, being conſiderably greater at the bottom of the ſand than at the top. The utmoſt heat uſually given to the ſand-bath is that of low redneſs, and it has the advantage of keeping very hot for a long time, without any additional fuel.

In a few inſtances ſtrong brine, or mercury, are uſed as balnea. The former when boiling is conſiderably hotter than ſimple water, ſo that water immerſed in boiling brine may be brought fully to the boiling point. Mercury will receive a much greater heat, and it perhaps might be more frequently uſed with advantage than it is at preſent, for heat penetrates through it with much more rapidity than through water, and every veſſel uſed in chemiſtry with their materials, will float upon its ſurface. The mercury ſhould be in an iron pan, and ſhould be kept much below its boiling or evaporating point.

The terms water and mercury bath are often uſed, though not quite correctly, for the Pneumatic Troughs of theſe fluids uſed in operations on gaſſes (which ſee).

BELL GLASS. BELL RECEIVER. Pl. I. Fig. 17.—IV. 52.

This is a very uſeful form to be given to large glaſs veſſels in a variety of experiments on gaſſes, particularly where any vacuum is produced, as the vaulted form of the veſſel reſiſts the great force of atmoſpherical preſſure. It is therefore employed in experiments with the air-pump.

BLAST FURNACE. See Furnace.

BLOW-PIPE. Pl. VII.

When a ſmall jet of air is directed laterally into the middle of the flame of a lamp or candle, a portion of the flame is diverted in the direction of the jet, and forms a long ſlender cone of flame, the heat of which increaſes towards the end of the cone, and at the very point its intenſity is extreme. This affords a moſt convenient way of heating in a very high degree with a moſt cheap and ſimple apparatus, and almoſt inſtantaneouſly, any ſubſtance minute enough to be involved by the flame, and of performing a vaſt number of experiments by which the nature of ſubſtances may be diſcovered, though the actual quantities employed are generally too minute to enable the chemiſt to aſcertain relative proportions with accuracy.

The inſtrument by which the jet of air is produced, is called the blow-pipe, of which there are ſeveral kinds. The moſt common is that uſed by the mouth, and need not be more than a tube of braſs or any other material, bent near the end the furtheſt from the mouth, and drawn out ſufficiently fine to keep up a conſtant rapid ſtream of air by the ſupply that the mouth is able to furniſh.

But as in the courſe of blowing, the moiſture of the breath is apt to condenſe in a troubleſome quantity, an improvement has been adopted of making a bulb near the ſmall end of the pipe, which, to render it more portable, is divided through the middle, and the two parts ſcrew together when uſed. Fig. 73 *a b* is a common braſs blow-pipe of this kind, and inſtead of the pipe itſelf terminating in a ſufficiently ſmall opening, a ſeparate jet-pipe (Fig. 72) is ſlipped on, of which there are two or three different ſizes in the bore, according as a larger and more moderate, or a ſmaller and more intenſe flame is required.

Fig. 71 is a blow-pipe of the ſame kind, but ſtill more convenient. It contains, like the former, a circular enlargement to condenſe the moiſture, but the ſmaller end *d* is moveable in any direction round the center *c*, whereby any degree of obliquity may be more conveniently given to the flame. The jet pipe, Fig. 72 is uſed as in the laſt, and an ivory mouth piece, *b*, ſlips on the larger end, being pleaſanter to the lips.

The beſt kind of flame for blowing through with the common blow-pipe is a wax or tallow candle with a very large wick, which ſhould be kept ſnuffed moderately low, and the wick turned a little aſide from the pipe. A ſpirit lamp is ſometimes uſed, which makes a perfectly clear flame without ſmoke, but weak when uſed in this way. There is a kind of knack in blowing with the mouth, which is not eaſily deſcribed, and requires a little practice to be performed with eaſe. As the flame muſt often be kept up for ſeveral minutes, the act of reſpiration muſt be carried on through the noſtrils without interruption, and the ſtreſs of blowing muſt be performed merely by compreſſion of the cheeks upon the air in the mouth.

The ſubſtance to be heated is placed either on a piece of charcoal or a metallic ſupport. When the former is uſed, a large cloſe well-burnt piece of charcoal muſt be choſen, a ſmall ſhallow hole ſcooped out with a knife, and the ſubſtance laid upon it. The charcoal itſelf kindles all round the hole, and the hole is thus gradually enlarged; and the heat too is kept up round the ſubſtance much more uniformly than when a metal ſupport is uſed. At the ſame time however the chemical effect produced by heated charcoal ſhould not be forgotten, particularly the reduction of metallic oxyds, and the deoxygenation of the fixed acids; ſo that, for example, a ſmall heap of minium or litharge heated red-hot on charcoal by the blow-pipe, is ſpeedily reduced to a globule of metallic lead; the phoſphats are partially reduced to phoſphurets, &c.

For a metallic ſupport, platina is in general by far the beſt material. A ſmall ſpoon of this metal is repreſented of the real ſize in Fig. 74; the ſhank of which may be ſtuck in a cork when held. Fig. 70 is a ſmall ſilver cup, alſo of the real ſize, the ſhank of which is fixed into a wooden handle. Fuſions with borax or alkaline fluxes may be performed in them. Fig. 75 is a ſmall forceps lately brought into uſe, and made entirely of two thin pieces of platina joined by rivets and bent in the manner repreſented. Any ſmall hard ſubſtance may be held by them in the blow-pipe flame for any length of time without danger of the points of the forceps melting, and it is also found that this metal is ſo much worſe a conductor of heat than any other, that the forceps never get too hot for the naked fingers to touch at the bend.

In the common way of uſing the blow-pipe there is this inconvenience, that one hand of the operator is employed in holding the pipe, and the other, the ſupport; ſo that he cannot turn, or in any way manage the ſubſtance heated, nor trim the lamp without ſtopping the proceſs. Several contrivances have been employed for ſupporting one or the other, and giving the operator the free uſe of one or both his hands, ſome of which are complicated enough, eſpecially where a candle is uſed, as in this the height of the flame is always altering as it burns away. The little apparatus, Fig. 76, is perhaps as convenient as any, where a lamp is uſed. The kind of lamp here repreſented is of the ſhape of a ſlipper, and when employed by the glaſs-blowers, the wick is a large ſkein of cotton, and the blaſt is made by double bellows that are fixed beneath the table and worked by the foot of the artiſt, who ſits before the lamp, and thus has both his hands and mouth at liberty. The ſmoke given out by this kind of lamp is ſo much that it is neceſſary to have a ſmall iron chimney with a flue hanging juſt above it. (See the article *Glaſs*, Vol. I. p. 503.)

Another method of keeping up a continued ſtream of air without either the mouth or bellows is to fix a blow-pipe tube to the air tube of a gazometer, Pl. V. Fig. 61 & 2, *e* filled with common air, and the ſtrength of the jet may be increaſed by leſſening the counterpoiſing weights. (See the article *Gazometer*.) The ſame apparatus alſo affords an opportunity of giving in a ſmall ſpace the higheſt poſſible heat that combuſtion can procure, by ſubſtituting oxygen gas to common air in the gazometer. Hence it is of advantage to have the jet pipes tipped with platina, for if they are of braſs, they are liable, without conſiderable care, to melt down by the intenſity of the heat produced, or if of iron, they might readily be burnt. Some of the effects of this intenſe heat on refractory bodies are related under the article *Oxygen*.

A very ingenious blow-pipe has been invented (we believe by Mr. Paul of Geneva, known by his excellent preparations of the artificial mineral waters) which conſiſts in paſſing the vapour of boiling alcohol through the flame of a lamp, whereby it is kindled, and produces a very large cone of clear blue flame, perfectly free from ſmoke, and of ſufficient intenſity to melt ſmall quantities of glaſs for barometers and thermometers, and for many other uſeful purpoſes. Every part of this apparatus is entirely independent of the artiſt, ſo that he has both his hands and mouth at full liberty.

A repreſentation of Mr. Paul's alcohol blow-pipe with a few alterations is given in Pl. VII. Fig. 69. The whole is neatly turned in braſs, and conſiſts of the following parts.

a is a hollow oval frame about 5 inches in its longeſt dimenſion, which ſupports the pillar *d* and the two lamps *b c*, which may burn either oil or alcohol, but the latter is the beſt. The rim *e e* ſlips upon the pillar *d* as low as the ſhoulder of the latter will permit, but the rim may be raiſed at pleaſure and kept faſt by the ſcrew-peg *f*. The rim ſupports the boiler *g* which is a ſingle hollow piece of thick braſs which will hold about an ounce of alcohol, and has four openings, viz. three at top *h*, *i k* and one at bottom to receive the tube *o*. This latter is long enough to reach to the level of the outſide of the top of the boiler, and conſequently the alcohol within the boiler cannot readily boil over into the tube, and the opening *k* which correſponds with it, is cloſely ſhut by a ſcrew ſtopper, hollowed out a little beneath, to allow the free paſſage of the vapour down the tube. Here the vaporized alcohol is prevented from condenſing at the point *o* by the contiguity of the flame of the lamp *b*, and as it paſſes on through the hollow *p q* into the jet tube *r*, it is immediately kindled by the flame of the lamp *c*, and the united flames are compelled ſideways with ſuch violence as to form a long pencil of blue flame, attended with a conſiderable roaring noiſe. This continues as long as any alcohol is left in the boiler, which allows ample time for moſt blow-pipe operations. The boiler is filled at the opening *h*. The centre hole *i* is nicely fitted with a ſmall braſs plug kept down by a thin ſlip of iron *l*, the other end of which ſlips over the top of the upright pillar *d*, and is confined between two flat ſcrew-plates *m n*. The uſe of this is as a ſafety valve to take away all danger of the boiler burſting by the confined vapour not being able to eſcape faſt enough through the jet-pipe *r*, for when the internal preſſure is great, the elaſticity of the iron ſpring *l* allows the valve *i* to riſe ſufficiently to let out part of the encloſed vapour. The ſcrew ſtoppers *h* and *k* are made ſtill tighter by collars of leather, as is the part where the tube *o* joins the boiler. The jet-pipe *r* has a compleat rotatory motion, ſo that the flame may be compelled in any direction. This is effected by turning in the form of a ball that part of the pipe which is encloſed in the hollow *p q*.

BURNING GLASS and MIRROR. See Solar Heat.

CALORIMETER. See the article *Caloric*, p. 216 in the former part of this Dictionary.

CAPITAL. A capital or head, is the upper part of an alembic, or other diſtilling apparatus, in which the condenſation of the vapour begins. See Distilling *Apparatus*.

CARBOY is a very large glaſs veſſel of the form of a compreſſed globe, with a ſhort neck, uſed by the manufacturers for containing ſulphuric acid. It is generally protected by a baſket of wicker work.

CRUCIBLE. Pl. I. Fig. 22 and 26.

A crucible is a pot generally made of clay, but ſometimes of other materials, and intended to bear a ſtrong heat. (For ſome obſervations on the quality of theſe fire-veſſels ſee the article Pottery, in the former part of this work). The common ſhape of the earthen ware crucibles, is either three-cornered or round, and they are fitted with ſtoppers of the ſame materials, (Fig. 23 and 27) perforated with a ſmall hole, opening obliquely to allow the eſcape of any volatile matter, and to prevent any of the fuel from dropping in. As the lower part of the crucible would eſcape the greateſt intenſity of heat, and would be liable to crack by the draught of air if it was ſet directly upon the grate of the furnace, it is uſually raiſed about two inches by a ſmall ſtand, which may be either ſolid Fig. 24, or hollow Fig. 25. The latter when inverted, alſo forms a convenient ſtand for an earthen retort. The lid of the crucible may be luted on, when neceſſary, with any kind of fire lute (as already deſcribed in the article *Cement*, Vol. 1.) particularly with the mixture of borax and clay. It is often of advantage to line the crucible with charcoal, for example, in the reduction of metallic ores that require no flux, ſuch as the black oxyd of manganeſe. Chemiſts have uſually done this by fitting into the crucible a ſolid piece of cloſe well-burnt charcoal, and ſcooping out a hole in the latter; but it is a much more convenient way to mix ſome powdered charcoal with a very little linſeed meal, to moiſten it with juſt ſo much water as will bring the mixture to a ſtiff paſte, and to line the crucible with it when wet. On applying heat, the linſeed meal burns, and gives out a little flame and ſmoke which eſcape through the hole of the cover, but this does not derange the charcoal lining.

Crucibles are alſo made of caſt-iron, of fine ſilver and of platina. The former are ſometimes of advantage in analyſes where a very ſtrong heat is required to be given to ſubſtances in contact with alkaline fluxes, but they are ſeldom uſed. Silver crucibles are employed with great utility in the common analyſis or reſolution of minerals by cauſtic alkalies; and they are alſo extremely ſerviceable in a variety of other experiments, where a heat not exceeding moderate redneſs is required, and where the ſubſtances do not act upon this metal.

The uſe of platina for crucibles has ſo much increaſed of late that it is conſidered as eſſential to a well-furniſhed laboratory, and indeed not without reaſon, as there is no ſubſtance that unites ſo fully the qualities of infuſibility at almoſt any heat with reſiſtance to the action of almoſt every chemical reagent. The cauſtic alkalies however have ſome diſſolving power on this metal as is mentioned under the article *Platina*. Where a crucible of this metal is uſed for very high heats, particularly in fires ſupplied by coal or coak, it ſhould be looſely incloſed in a refractory earthen crucible, otherwiſe the vitreous ſlag of the coal is apt to encruſt the outſide of the platina veſſel, and adhere to it with ſo much force that it can hardly be got off without great violence.

CUCURBIT. Pl. II. Fig. 39. *a*.

This is an oblong glaſs veſſel with a very wide mouth (nearly of the form of a long *gourd*, whence its name) uſed for various chemical purpoſes, and in particular it forms the body of the common glaſs alembic.

CUPEL. Pl. I. Fig. 28 and 29.

This is a ſolid paſte of bone-aſh moulded in a ſhort cylindrical or truncated pyramidal form, with a ſhallow circular cavity at the top, about the ſize of a ſegment of a large bullet. It is uſed in the proceſs of *Aſſaying*, (which article ſee in Vol 1. p. 110.) In making cupels the powdered bone-aſh is moiſtened with a very little water, and the maſs is made into the required form by being ſtruck with conſiderable force into a mould of braſs or iron, and afterwards gradually dried. By this means it acquires ſufficient hardneſs for the uſe to which it is put.

DETONATING JAR. Pl. VI. Fig. 67.

It is frequently neceſſary in the analyſis of ſome gaſſes to take the electric ſpark on given quantities in cloſe veſſels, ſuch as mixtures of oxygen and hydrogen, which laſt forms the eudiometer contrived by Volta, and bears his name. It conſiſts of a thick glaſs tube quite open at bottom, and near the top are two perforations in which ſmall wires are cemented that approach each other within the jar near enough to communicate the electric ſpark, from an adjoining machine, whereby the incloſed gaſſes are fired. In moſt caſes where this apparatus is uſed it is with mixtures of gaſſes that detonate ſtrongly when fired, which is attended with ſome inconveniences. If the jar in which the experiment is fired is cloſely ſtopped a very ſmall quantity of hydrogen and oxygen will burſt pretty thick glaſs; and if it is entirely open, ſo that all the force of the exploſion may be ſpent on the liquid in which the lower end is immerſed, a good deal of it (eſpecially if it be mercury) is thrown out and diſperſed to a diſtance. Theſe inconveniences are entirely remedied by the detonating jar deſcribed in the Plate (invented by Mr. Pepys) in which the jar is ſupported by the heavy iron ſtand *c*, which has a ſtrong ſpring near the foot that draws out in the manner of the ſteel-yard when the concuſſion is given; and thus much larger quantities may be ſafely detonated than can be done by the common apparatus, without ſpilling any of the mercury. The ſhock is taken by wires that paſs through the holes *a* and *b*.

DIGESTER.

A digeſter is a thick iron boiler furniſhed with a ſtrong lid perfectly tight, that may be ſcrewed down with force ſufficient to reſiſt the expanſive force of the incloſed ſteam, whereby the water or other liquid which it contains may be heated conſiderably higher than the natural boiling point of water when unconfined. But as the ſtrength of the veſſel diminiſhes, and the force of expanſion increaſes as the heat is raiſed, there is a point at which the veſſel would burſt, and a dangerous exploſion would take place, if it were not prevented by a ſafety valve, with which all theſe veſſels are furniſhed, and which will open and let part of the confined vapour eſcape when the expanſion has reached a certain point. There are ſome caſes where a digeſter proves an uſeful part of chemical apparatus, but it is not often employed.

DISTILLING APPARATUS.

Under this article we ſhall deſcribe the different kinds of alembic, the common ſtill, with its worm-tub, and the other apparatus for ſimple diſtillation, or that in which the ſole object is to condenſe and collect in a liquid from the heated vapour of any ſubſtance. When a part of the product to be collected is either a permanently elaſtic gas, or a vapour which requires to be paſſed through water or any other liquid in order to be condenſed, it is neceſſary to employ a more complicated apparatus ſimilar to that which was originally invented by the late Mr. Woulfe, and will be deſcribed under the article WOULFE'S APPARATUS.

The ſimpleſt apparatus for diſtillation with moderate quantities is the Retort and Receiver. The former is made either plain (Pl. I. Fig. 5.) or tubulated and fitted with a ground ſtopper Fig. 2. It ſhould be roomy at the bend, as it is there where the vapour firſt begins to condenſe. When the plain retort is uſed, the materials to be diſtilled, if liquid, ſhould be poured in by a very long funnel, ſo that none of it may trickle down the neck. The bottom of the retort where the heat is applied is blown pretty thin, and being of uniform thickneſs it will always bear the heat of an Argand lamp, or even it may be ſlung upon a ſmall chain over a common open coal fire when burning clearly, with very little riſk of breaking, if tolerable caution be uſed. The neck of the retort paſſes into that of the receiver, or ſometimes with the intervention of an *Adopter* (Fig. 3.) and the joinings ſhould be luted. The receiver ſhould be of conſiderable capacity compared to the retort, ſuch as Fig. 4. to Fig. 2. to allow a large cool ſurface for the condenſing vapour, and it may be further kept cool by covering it looſely with a cloth frequently wrung out of cold water. The receiver may be either a ſimple globe with a neck Fig. 6, or may be drawn out into a long tube at bottom, as in Fig. 4, in which caſe the tube ſhould enter a bottle placed beneath.

When the receiver is tubulated it gives the advantage of allowing all the joinings between it and the retort to be perfectly air-tight, without danger of the veſſels burſting by the expanſion.

The alembic employed for diſtillations in larger quantities than with the common ſized retorts is repreſented in Pl. II. Fig. 33 and 34; the latter of which is a ſection of the former. This is taken from a drawing of a very excellent alembic made of tinned copper, almoſt exactly the ſame as that given by Beaumé in his Elements de Pharmacie, and uſed by that excellent practical chemiſt. It contains beſides the eſſential parts of the apparatus the very uſeful addition of a water bath, which may be employed or taken out at pleaſure. This apparatus conſiſts of the four following pieces: *a a* Fig. 33 and 34 is the boiler, which is let in to a portable furnace to the height of the ſhoulder. It has a ſmall opening at the upper part, ſtopped with a cork, by which freſh liquor to be diſtilled may be poured in during the proceſs of diſtillation without deranging the apparatus: *b b* is the water bath which ſinks almoſt to the bottom of *a*, and is therefore kept entirely ſurrounded with boiling water. *c* is the capital or part in which the condenſation of the vapour begins. It is only ſeen in Fig. 34, being hid in Fig. 35 by the veſſel *d*. The capital is of a conical ſhape, and at the lower part of the cone a ſmall gutter is made by a doubling of the copper plate, which terminates in a conducting pipe that points obliquely downwards. The capital *c* is entirely incloſed and cemented into the refrigeratory *d*, ſo as to make but one piece with it. The uſe of the veſſel *d* is to contain cold water, which by cooling the outſide of the capital *c* facilitates the condenſation of the vapour within it and cauſes it to flow in a ſtream down the conducting pipe. *e* is a cock belonging merely to the refrigeratory *d*, to let the water off when too much heated by the boiling vapour in the capital. The veſſel *d* has alſo two handles, by which it may be lifted on and off more conveniently. This apparatus is ſo conſtructed that the water bath *b* may be entirely removed, in which caſe the capital with its refrigeratory cloſes directly upon the boiler *a*, which then contains the matter to be diſtilled. A capital and refrigeratory fitting upon a ſmall boiler is alſo ſhewn in Fig. 35. This is often made of block tin, and is very uſeful in diſtilling water for chemical purpoſes with little trouble.

There is however one diſadvantage in the alembic with the refrigeratory thus placed on the top of the apparatus, which is, either that the water of the refrigeratory ſoon gets ſo warm as not to be able effectually to condenſe all the vapour; or if it is kept conſtantly cold, a conſiderable part of the condenſed vapour drops back again into the boiler, which is directly beneath it, and thus the proceſs is prolonged, beſides the danger of altering the quality of the product by the long heating. To remedy this defect ſeveral chemiſts (and among them Beaumé) have added to the alembic a ſerpentine or worm tub (ſuch as is repreſented in Fig. 32,) into which the conducting pipe of the capital opens, and it is this addition probably which has led to a great ſimplification of the apparatus, by removing entirely the refrigeratory round the capital and cauſing the whole of the condenſation to be performed in the ſerpentine. This forms the common ſtill with its adjoining worm-tub, which is now uſed with ſome variety of conſtruction almoſt excluſively in this country both in the large way in the vaſt manufacture of diſtilled ſpirits, and where only a few pints of diſtilled liquor are wanted, and which has, with us at leaſt, almoſt entirely ſuperſeded the old alembic.

The common ſtill, Fig. 31, conſiſts of only two parts, viz. *a* the boiler, which is here ſhewn as partly buried in a portable furnace; and *b* the head or capital, which conſiſts of a pretty large hollow globe, the upper part of which is drawn out into a curved pipe that makes a compleat arch and terminates at *c* Fig. 32, where it enters the upper part of the ſerpentine, or worm. This latter is a long pipe made of pewter, with a decreaſing diameter to the bottom, and fixed in a tub filled with cold water, which effectually condenſes the vapour, ſo that the liquid falls in a thin regular ſtream from the lower end of the ſerpentine. The joining between the boiler and head of the ſtill generally requires a ſlight luting, for which ſlips of paper dipped in paſte, or of wet bladder neatly applied over the circle of junction is ſufficient. The line of tube from the bend of the ſtill-head to the very bottom of the worm-pipe ſhould be a gradual uniform ſlope downwards, and ſome nicety is required in the maker to give the ſerpentine that regular falling ſpiral line which is found the moſt favourable to ſpeedy condenſation. The chief diſadvantage of the ſpiral worm-pipe is the difficulty of cleaning it and getting out the remains of any ſtrong-ſmelling ſubſtance, ſuch as an eſſential oil; whereas the large alembic capital is eaſily cleanſed.

For diſtillation of ſmall quantities of eaſily condenſible ſubſtances, where much nicety and cleanlineſs is required, the glaſs alembic, Fig. 39, is highly uſeful. It conſiſts of two pieces, viz. *a* the cucurbit or boiler, the bottom of which is made thin ſo as to bear a lamp-heat, and *b* the capital. Theſe are ſometimes made tight by luting and ſometimes by grinding. The beak of the capital may paſs into the glaſs balloon *c* or into any other convenient veſſel, which laſt may alſo be ſurrounded with cold water or ice, if required. The glaſs alembic is in ſome reſpects better than the retort and receiver, inaſmuch as the veſſel to which heat is applied can be got at much more eaſily to be filled or cleanſed, but it is an expenſive apparatus and liable to accidents.

The old veſſel called the Pelican Fig. 38, is a kind of alembic ſo contrived as to allow the diſtilled liquid to fall down again perpetually into the veſſel whence it was expelled. An improvement on it, Fig. 37, is of the ſame kind. See PELICAN.

DOME is the upper part of ſeveral kinds of furnace, round which the flame of the fuel reverberates before it enters the chimney. See FURNACE.

EUDIOMETER.

The various proceſſes belonging to *Eudiometry* or the aſcertaining the purity of the air have been mentioned under that article in the former part of this work. Some of the moſt convenient veſſels for that purpoſe may be here deſcribed.

Pl. I. Fig. 18. is a graduated jar for meaſuring gaſſes. It is made wider at bottom to ſtand more ſteadily. There are two ways of graduating jars, either of which any one may readily perform for himſelf. Select a very ſmall phial or tube which will exactly hold, when brimfull, an aliquot portion of a cubic inch, which is determined by weighing the contents, allowing for the cubic inch at 60° temperature 252½ grs. of diſtilled water. Fill the eudiometer jar with water at 60° invert the empty phial under it, and turn it up when within the jar, by which means the required portion of a cubic inch of air will riſe to the top of the jar. Paſte a long ſlip of paper round the level of the water in the jar, and then repeat the ſame operation till the whole is graduated. The lines may then be marked with a diamond, or a fine three-cornered file, and numbered, and the paper ſcraped off.

In graduating a jar in this method there is a little trouble in getting a phial to hold the preciſe quantity, and it will be more accurate if the rim round the neck is taken off and the edges ground ſmooth. If the required weight of water does not quite fill it, a ſmall pellet of wax or cement may be added, and this may afterwards be melted upon the bottom of the phial to diminiſh its capacity. In graduating a jar in this manner, the hand of the operator ſhould touch the phial only for an inſtant, and at the thickeſt part of the glaſs, to avoid the expanſion of the contained air by the warmth of the hand.

Another method of graduating is to weigh in the jar itſelf ſucceſſive portions of diſtilled water correſponding with the diviſions of the cubic inch intended to be marked, and to ſcratch the levels by the file or a diamond. This is in ſome reſpects more accurate than the former, as, with tolerable care, it obviates all danger of any ſenſible error from accidental changes in temperature, the whole meaſurement being made with water in which the difference of a degree or two is ſcarcely felt. There is only this circumſtance to be obſerved, which is, to carry the lines of diviſion nearly round the whole circumference of the jar, otherwiſe ſome deception may eaſily ariſe in the uſe of it, unleſs the ſurfaces of the top and bottom of the jar are exactly parallel to each other; for when graduated by ſucceſſive quantities of water, it is obvious that the jar muſt ſtand on its cloſed end, and the contrary when graduated by portions of air.

The above inſtrument is ſimply a graduated jar and therefore ſomewhat improperly called an *eudiometer* jar, but two or three direct eudiometrical veſſels have been contrived whereby the ſubſtance intended to analyze the contained air by abſorbing a portion may be conveniently applied to it.

Dr. Hope's eudiometer is the following: Pl. IV. Fig. 55.

It conſiſts of two parts, the lower of which is a ſhort thick bottle with an upper and a ſide opening (the latter cloſed by a glaſs ſtopper) and the upper part is a graduated tube cloſed at top and accurately fitting into the lower bottle by grinding. To uſe it, take off the tube and fill it quite full with the gas to be examined, and alſo fill the bottle with the eudiometrical liquid (ſulphuret of lime for example) and without ſhaking it, ſink it in water. Then, immerſing the open end of the tube in the ſame veſſel, bring it over the bottle and thruſt it in. The bottle and tube may then be taken out, and well ſhaken, that the liquor may thoroughly come in contact with the contained gas, and the bottle from time to time immerſed again under water, and the ſide ſtopper a little looſened that the water may ruſh in to ſupply the partial vacuum produced by the abſorption. This will indeed ſomewhat dilute the eudiometrical liquor, but not ſo as to prevent it from acting. When no more abſorption takes place the proceſs is finiſhed, (which only requires a few minutes at longeſt) and the abſorption is noted at once by the graduated ſcale ; or if the tube is not graduated, the reſidual gas may be transferred to another that is.

Another eudiometer which is intended merely for the analyſis of the atmoſpheric air of any ſituation, is that of Mr. Davy, Pl. IV. Fig. 56. which conſiſts ſimply of a portion of glaſs barometer tube, bent into two legs of equal length, both of which are furniſhed with glaſs ſtoppers, and one of them graduated. It is uſed in the following way. The tube is of courſe filled with the air of the place which it occupies, or for greater certainty, it maybe firſt entirely filled with water, and then inverted, by which the adjoining air will come in as the water falls out. Then holding it with the bend lowermoſt, and both the ſtoppers out, drop down through the plain or ungraduated ſide a little water, till it reaches the beginning of the graduation, and cloſe the graduated ſide with the ſtopper, ſo that the air occupies exactly the whole of the graduated ſpace. Then pour down the plain ſide upon the water the eudiometrical liquor (ſulphat of iron holding nitrous gas in ſolution) till this ſide is quite full, and cloſe this ſtopper alſo. The whole cavity will then contain a known portion of air in contact with the proper liquor, which by agitation will abſorb all the oxygen of the air in a few ſeconds, and by looſening the ſtopper of the plain ſide under water, the reſiduary gas on the other ſide will ſhrink to its proper volume, and may immediately be eſtimated.

Volta's eudiometer for the detonation of the incloſed air, with meaſured portions of hydrogen, has been already mentioned under the article *Detonating Jar*.

EVAPORATING VESSEL.

Evaporation is one of the commoneſt operations in chemiſtry, and in the ſmall way may be performed with ſufficient eaſe in almoſt any open veſſel. The evaporating veſſels made for this expreſs purpoſe are ſometimes of metal, but generally either of glaſs or earthenware. The glaſs veſſels uſed in this country are ſegments of ſpheres blown thin enough to bear a lamp heat, and ſold in aſſortments of different ſizes, from the capacity of nearly a pint to that of about an ounce. A broken matraſs or Florence flaſk, cut round, will anſwer the purpoſe extremely well. The globular ſhape of all theſe veſſels however renders them difficult to heat, but it is difficult to get glaſs much flatter at bottom and retaining that uniform thinneſs which is neceſſary to make it bear the application of heat.

Very convenient evaporating veſſels nearly flat-bottomed, are made by Meſſrs. Wedgwoods, and ſold in neſts or aſſortments, the largeſt of which will hold 8 or 10 pints. They are ſometimes plain, ſometimes with a lip in the upper edge, that the liquor they contain may pour better. The ſhape of a plain evaporating veſſel is ſeen in Pl. I. Fig. 9. They are made either with or without glazing. Even when unglazed they hold any liquor without ſoon imbibing it, as the texture is a very denſe, hard, biſcuit porcelain ; though in great length of time ſaline ſolutions will make their way through, and ſhew themſelves in effloreſcences on the outſide.

Theſe evaporating veſſels will bear to be heated to boiling, over a clear hot fire, ſuch as that of charcoal or cinders, but they are liable to crack when expoſed to jets of flame, or unleſs heated with ſome caution at firſt. No liquor ſhould be boiled to dryneſs in theſe veſſels, as they generally crack whilſt the laſt portion of fluid is expelled unleſs the heat is much lowered.

FILTER. Filtration.

Filtration is conſtantly required in chemical proceſſes, in order to ſeparate fluids from ſubſtances ſuſpended in them. In moſt inſtances it is performed by throwing the whole upon a conical bag made of any porous materials, ſuch as flannel, linen, or paper, which detains the ſolid part, and allows the fluid to paſs through clear. Where the quantity of materials is large, and the ſolid is of a nature to be not eaſily ſuſpended in water, a flannel or linen bag is preferable, as it is much more expeditious than paper. Thus for example, where in the firſt ſtep of making phoſphorus, bone-aſh is decompoſed by ſulphuric acid, and the whole diluted with much water, the liquor is obtained very clear by throwing the whole on a conical linen bag ; and though the firſt few ounces may be turbid, the runnings ſoon become perfectly limpid. Where the object is, as in this caſe, to preſerve the liquor that runs through, linen is preferable to flannel, as the latter ſoaks up a larger quantity of liquor, which muſt be got out by ſubſequent waſhing and wringing. But where the ſolid reſidue is the only valuable part (as in filtering the citrat of lime formed by chalk and lemon juice) flannel anſwers as well and is more ſpeedy. In ſmall quantities, and where accuracy is required, the material of the filter is generally a ſquare thin unſized paper, firſt doubled from corner to corner into a triangle, and the latter again doubled into half the ſize, making another triangle. This when opened forms a paper cone, into which the liquor is poured, and which muſt be ſupported by being put into a glaſs funnel. There is always ſome little loſs of materials incurred by filtration, particularly of the fluid which paſſes through, for the paper muſt of courſe abſorb a quantity of it, and though after the firſt filtration, the filter is repeatedly filled with warm water, it is impoſſible to waſh out every particle of the ſaline ſolution with which it was at firſt impregnated. This is one reaſon why in all analyſes of minerals in the moiſt way, the ſum of products obtained by the moſt accurate experiments always falls ſhort a little of the original weight of the mineral employed; ſo that if they ſhould prove exactly equal, there is reaſon to ſuſpect ſome little error in the computation, or a want of deſiccation in the products equal to that of the ſubſtance uſed.

To collect at the bottom of the filter every particle of the reſidue, it is very uſeful to have a ſmall glaſs tube open at both ends, and drawn out into a very fine capillary point at one of them. When this is filled with diſtilled water and the larger end put into the mouth, the force of the breath can direct a ſmall ſtrong ſtream of water round the ſides of the paper funnel, which will waſh down to the bottom every minute particle of ſolid ſubſtance. When the filtration is finiſhed and the reſidue properly edulcorated, it muſt be dried in part before it can be taken clean off the paper. Sometimes the quantity of reſidue is ſo minute, and ſticks ſo much to the paper, that it cannot be ſcraped off when dry, at leaſt not with ſufficient accuracy; as, for example, where the quantity of ſulphuretted hydrogen of a mineral water is to be eſtimated by precipitating and weighing the ſulphur. In ſuch caſe the moſt accurate way is to filter as uſual, but inſtead of attempting to remove the reſidue, to weigh it againſt another piece of filtering paper previouſly cut exactly of the ſame ſize as the filter, wetted, and dried at the ſame temperature, and the difference in the weights will indicate the quantity required.

The ſubſtances that cannot be filtered in the common way, are thoſe which act too powerfully upon the paper and other materials employed. The concentrated acids and alkaline ſolutions are of this kind. Where it is required to filter them, which is not often the caſe, they may be poured through a ſtratum of coarſely powdered glaſs, or well waſhed white ſand, in a glaſs funnel. See FUNNEL.

A convenient ſtand for filtration with a drawer at bottom to hold filtering paper, &c. is ſhewn in Pl. VI. Fig. 65.

FLASK.

This hardly differs from the *Matraſs*.

The flaſks of green glaſs ingeniouſly covered with ruſhes, in which the fineſt oil is imported from Italy, form very uſeful chemical veſſels and at a low price. They are extremely thin, and will bear heat very well, and being made of a hard glaſs without litharge, they will bear a low red heat without materially ſoftening or loſing their ſhape. On this account too they are the beſt veſſels for performing ſublimation in, with ſmall quantities of materials, and if neceſſary they may be coated for this purpoſe by diffuſing clay in water to the conſiſtence of thick cream, and dipping the flaſk in up to the neck, repeating the operation ſucceſſively as ſoon as each coating dries.

The flaſks muſt firſt be cleaned by a little ſand, and any refuſe ſolution of alkali, ſomewhat cauſtic, boiled in it, and ſhaken about till all the oil within is diſſolved. Very uſeful cup-ſhaped veſſels for evaporation and other purpoſes, may be made by cutting off one of theſe flaſks round the bottom of the neck or the middle. This is done with eaſe in the following way: if the flaſk is ſound, heat a piece of the thickeſt iron wire fully red-hot, and lay it on the part you wiſh to divide, moving it backwards and forwards ſlowly in the intended direction of the crack. This will generally ſucceed in beginning the crack, after which it may be led along with extreme eaſe, ſimply by bearing gently with the hot iron in the courſe which the crack is to purſue, till the diviſion is compleat. But among a number of flaſks there are generally ſome that have a little crack or flaw in them, and this may be led over any part of the veſſel by the ſame means, and will cut it to the required ſhape. It ſhould be remembered however, that though it requires a very hot iron to ſplit a ſound flaſk, yet when the leaſt crack is made, it may be led along by a much leſs heat, and the cooler the iron is, the leſs likely the crack is to deviate from the intended direction. If the flaſk is ſplit in the contrary direction, that is, perpendicularly through both the neck and body, it forms two ſimilar glaſſes extremely convenient for many ſmall operations, and in which the ſplit part of the neck ſerves both as a ſpout and handle. The greateſt inconvenience attending theſe veſſels made out of flaſk, is their exceſſive thinneſs at the middle, ſo that they are liable to ſplit by the leaſt blow, and when full of liquor they can hardly be taken up without danger of being broken by the preſſure of the hand.

FORGE. See Furnace.

FUEL. See Furnace.

FUNNEL. The common funnel needs no deſcription. It may be made either of glaſs or pewter, or tinned iron, or earthen-ware.

The *ribbed funnel*, Pl. I. Fig. 7. is better for ſupporting large paper filters than the plain ones; for in the latter caſe, the wet paper adheres ſo cloſely to the ſmooth glaſs as moſt materially to prevent the paſſage of the liquor through; whereas the ribbed funnels afford as many channels through the whole length of the paper, by which the fluid is drawn down to the bottom. A plain funnel may be made equal or ſuperior to the ribbed, by arranging in a perpendicular direction at equal diſtances, a number of ſtraws, or pieces of thin glaſs rod, to form an uneven ſurface, over which the paper filter is to be laid, and thus to prevent its adhering to the ſide.

It is uſeful to have in a laboratory a ſmall glaſs funnel with a very long narrow neck, able to paſs down the whole neck of a retort, by which liquors may be poured in, without any part of them wetting the neck of the retort.

FUNNEL SEPARATORY. The ſeparatory funnel, Pl. II. Fig. 40. is intended for the ſeparation of liquids of different ſpecific gravity (as oil and water) by allowing the heavieſt only to drop out of the bottom of the veſſel. The funnel is firſt ſtopped at the bottom and then filled with the mixed liquors. When they have ſtood at reſt till the heavieſt has entirely ſubſided into the narrow part below, the cork at bottom is taken out, and when the ſtopper above is a little looſened the heavier liquor flows out. This veſſel is uſed particularly in ſeparating eſſential oils from the water which is neceſſarily entangled with them when collected from the water diſtilled from the plants that yield them. Some of theſe are lighter than water, others heavier, and they are both ſeparated with equal eaſe.

FURNACE.

As heat is one of the great agents in chemical proceſſes, the conſtruction of the apparatus through and in which heat is applied muſt be of the firſt conſequence, and accordingly a vaſt quantity of pains and ingenuity has been beſtowed on the ſubject of furnaces. To deſcribe every one that has been invented for general or particular purpoſes would far exceed our limits, we ſhall therefore only mention ſome of thoſe which are the moſt commonly employed in the laboratory. The furnaces required for working ores and metals in the large way, for making lime, bricks, pottery, glaſs, &c. are foreign from our preſent ſubject, and moſt of them have been noticed under theſe reſpective articles as fully as is conſiſtent with our general plan.

The furnace which is the moſt familiar to us is the *Common Grate*. This is an iron furnace of various ſhape cut down in front and the fuel kept in only by bars, in order to throw the heat out into the room. The utmoſt heat of a common parlour ſtove ſupplied with coals is barely ſufficient to melt thin plate ſilver, for a piece of ſilver money will not readily melt in it unleſs it burns very ſtrongly. But a very large number of the operations in chemiſtry are performed in a temperature not exceeding full redneſs, and for many of theſe the common grate is amply ſufficient. The flat iron ſides or cheeks will alſo furniſh an inferior heat, on which evaporating and digeſting veſſels may be ſet. The common grate however has two diſadvantages, one, that the openneſs of the front cauſes the eſcape of a great part of the heat, and incommodes the chemiſt in approaching it, and the other that coal is a very unſteady variable fuel giving much blaze and ſmoke, and requiring frequent ſtirring.

Before we deſcribe the proper chemical furnaces, we may ſhortly ſtate what muſt be their object and conſtruction.

The ſimpleſt air-furnace that we can conceive is a cylindrical or conical earthen pot, open at top and with a grate fixed within a few inches from the bottom, and a pretty large opening juſt beneath it, in order to allow of the draught of air through the fuel and for the aſhes to be cleared out. This draught-hole beneath the grate, of whatever form it be, is always called the *aſh-hole* or *aſh-pit*. If furniſhed with a ſtopper, the draught of air and conſequent intenſity of the fire may be regulated. The fuel is thrown in and the crucibles to be heated are introduced down the large opening at top. A cylindrical earthen pot thus conſtructed has already ſeveral advantages over the common grate of the ſame capacity; for the ſides being entirely cloſed, the whole of the air paſſes in beneath the grate and goes out above the fuel, whence the draught is proportionally ſtronger and the heat more intenſe, and it alſo may be approached without trouble. If a furnace of this kind is ſupplied with charcoal (which gives a much ſtronger heat than coal with a moderate draught of air) and the height above the grate is about double the diameter, a heat fully equal to the fuſion of a ſmall bulk of copper will be produced.

Still this is far ſhort of the temperature required for many operations, and therefore, (where the natural draught of air is reſorted to) it is neceſſary to increaſe this by incloſing the top of the cylinder with a dome of the ſame materials, which may be further elongated by a chimney of any height. The draught of air is now prodigiouſly increaſed, and if the ſides of the furnace are pretty thick, and the chimney broad enough and high enough, an intenſity of heat is produced, able to melt iron, reduce manganeſe, &c. in ſhort, to perform nearly all that artificial fire can do. It is by no means neceſſary that the chimney ſhould be perpendicular in every part, and it is often much more convenient that it ſhould quit the furnace in an horizontal or oblique direction, as it allows a much readier acceſs to the furnace and its contents.

The proportion which the diameter of the chimney ſhould bear to that of the furnace, to give the greateſt intenſity of heat, has been variouſly ſtated, and it ſtill ſeems not to be well determined. From ſome experiments of Darcet and Lavoiſier it would appear that the greateſt poſſible heat obtainable by air furnaces, is procured by making both furnace and chimney one very long upright channel or flue, perfectly open at bottom and at top, the furnace itſelf (or the part of the channel juſt above the grate) being bulged out in a moderate degree to give greater room for the fuel and the fire veſſels. In general however the flue of the chimney is made a little narrower than the aſh-pit. A cloſe furnace of this kind intended ſimply for heating any veſſel in the midſt of the fuel, requires eſſentially no more than three openings, namely, the aſh-hole, the chimney, and a ſide-door, through which to throw down fuel, and to introduce and take out the ſubſtance to be heated.

Where diſtillation by naked fire is wanted, a ſmall addition is required, and a hole muſt be cut level with the middle of the retort, through which its beak may emerge, and connect with the receiver or other veſſel intended to collect the product. The retort in this caſe is generally earthen.

Another object in furnaces is to apply a moderate degree of heat to larger veſſels, which therefore can only be partially in contact with the fire. Moſt of the furnaces uſed in manufactures and for many common purpoſes are of this kind, ſuch as the common houſehold coppers for heating water, brewing coppers, ſalt-pans, &c. &c. Sand pots are alſo of this kind, and in all theſe, the ſubſtance to be heated is placed over the fire, ſometimes dipping into it. This alſo eſſentially requires only three openings, viz. the aſh-pit, chimney, and door for fuel, the ſurface of the ſubſtance heated being external to the fire.

Another purpoſe in furnaces is to incloſe and heat on all ſides an earthen oven or muffle, the mouth of which at the ſame time comes in contact with one of the inner ſides of the furnace, and is freely acceſſible from without by a correſponding hole cut through the ſubſtance of the furnace. This therefore requires another opening beſides the three former already mentioned.

It is ſometimes required in experiments of reſearch to place an earthen or iron tube in ſuch a manner that the middle of it ſhall be ſtrongly heated whilſt each end is cool, and projecting beyond the furnace, ſo that no part of the contents of the tube can come in contact with the fuel. This is done in a cloſe furnace, by having two holes through the ſides directly oppoſite each other, through which the tube may be thruſt.

One more mode of diſtributing the heat of a furnace may be mentioned, which is, where the ſubſtance to be heated is neither incloſed in any veſſel, nor in actual contact with the fuel, but is ſpread on a kind of floor immediately beyond the fire in a ſpace between the fire-place and the chimney, and receives the heat from the flame which draws over it. This forms the reverberatory furnace, and requires a very peculiar conſtruction, as will be afterwards explained.

The above are the principal objects to be fulfilled in the conſtruction of chemical furnaces for general purpoſes, but another great diſtinction is in the mode of ſupplying air, which may be either by the natural draught of air, or by bellows or other artificial means. In the former caſe the rapidity of the current of air and conſequent intenſity of the fire, depends on having a ſufficient ſpace in the aſh-pit and chimney, and eſpecially a very great length of flue, and all the ſide-openings which would break the current, carefully cloſed. But with an artificial blaſt the ſtrength of fire depends ſolely on the degree of mechanical power employed in impelling the blaſt, and the chimney is altogether ſuperfluous except to carry off the ſmoke. Theſe kind of furnaces therefore are much ſimpler than the draught furnaces, as no more is required than a ſimple hearth or a ſhallow pot, with a ſmall hole at the bottom to conduct the air from the bellows. Large quantities of materials, as in the ſmelting of iron, can hardly be heated to the utmoſt intenſity without the artificial blaſt, and the aſſiſtance of a ſteam engine or ſome other very ſtrong mechanical force is neceſſary to keep up the conſtant ſupply of air. At leaſt, much time and fuel are ſaved by the blaſt, for if the heat of the moſt powerful draught-furnaces, ſuch as the porcelain kilns, may be brought to equal that of the iron-ſmelting furnace, it requires, however, a very large body of fuel and a great many hours to bring it to the utmoſt intenſity. But in the ſmall way, for experimental purpoſes, the higheſt temperature of a draught-furnace, when well built and properly attended to, appears to be no way inferior to the beſt blaſt, to judge by the comparative effects; and the greater conſumption of fuel and time is often fully counterbalanced by the ſaving of manual labour.

Some chemiſts have ſuppoſed that the heat of a furnace might be reflected from the ſides, and concentrated into one focus, by giving it a circular or elliptical form. This however is found by experience to be perfectly nugatory, for no ſenſible difference is obſerved between a cylindrical, globular, or elliptical fire-place, provided the dimenſions of the chimney and aſh-pit are the ſame. There is however a method of concentrating the heat of a blaſt-furnace, by dividing the blaſt into a number of ſmaller jets of air, and mechanically driving them towards a common center, as will be explained hereafter.

The materials of which furnaces are conſtructed is always a refractory clay, either in form of bricks, or, where the pieces of the furnace are ſmall, of entire pottery. The larger kinds of black-lead crucibles make extremely uſeful portable furnaces for a variety of purpoſes, being very infuſible, bearing pretty ſudden heating without ſplitting, and having the additional advantage of being ſo ſoft as to be readily drilled by a gimblet, and cut by a ſaw or hacked knife, whereby openings may be made and ſtoppers fitted without difficulty. Large moveable furnaces are often made of this kind of pottery, but much thicker than the common crucibles, and ſtrengthened on the outſide by iron hoops. A very uſeful white coarſe pottery is employed in France for portable furnaces, which bears the fire extremely well, but when baked is too hard to be cut like the black lead ware. Moveable furnaces are often made of a wrought-iron caſe lined on the inſide with ſmall fire-bricks, and the part immediately in contact with the fuel is further covered with a thick coating of Windſor loam, laid on when moiſt and plaſtic, and beat frequently with a wooden inſtrument when drying, to give it more compactneſs, and to fill up the ſmall cracks which the ſhrinkage occaſions. The fixed furnaces are always built of *fire-bricks* (a very hard infuſible brick, made for this expreſs purpoſe) cemented with a very refractory mortar; and the larger openings are either iron doors ſet upon hinges, or ſometimes a thick piece of free-ſtone, or very large brick properly faſhioned. There is a very ſoft red ſandy brick ſold in London, under the name of *Windſor brick*, which may be cut or ſcraped with great eaſe, and is extremely uſeful for ſtoppers, crucible ſtands, and many other ſmaller purpoſes, though it is too ſoft to bear any conſiderable preſſure.

A proper ſelection of the fuel is of firſt importance. Wood and charcoal were formerly the only materials employed for this purpoſe in this country, and are ſtill ſo in moſt other parts of the world; the firſt, where a large volume of flame is required, and the latter, for a ſtrong heat without flame. Thus glaſs-houſe and reverberatory furnaces were ſupplied entirely by dry faggots, and iron forges by charcoal.

Wood faggots give a ſtrong clear flame unmixed with ſulphur, and with but little ſmoke, and burn to a clean aſh, which alſo is valuable for the alkali it contains. From its freedom from ſulphur it muſt be in many inſtances better than coal, and it ſeems to have no other diſadvantage than the rapidity with which it burns out in a ſtrong draught, being ſo much more bulky than coal that only a comparatively ſmall quantity at a time can be thrown into a furnace. Hence in the large foreign glaſs-houſes that are fed by faggots, it is the work of one man to be inceſſantly adding fuel. But the ſcarcity of wood now forbids its uſe in moſt parts of this country, and the abundance of coal on the whole very well ſupplies its loſs.

Charcoal is a moſt valuable fuel for furnaces. It kindles readily, burns with a very ſtrong clear heat, and requires a much leſs draught of air for combuſtion than coak or charred coal; it contains no ſulphur nor any earthy or metallic matter, and hence it never runs into a hard vitreous ſlag as coak does, but burns away into a clean light aſh which falls through the bars of the grate, without choaking and hindering the draught of air, or melting down the clay walls of the furnace. The flues or chimnies alſo never collect any ſoot or foulneſs, and therefore never require cleaning. A much greater range of heat may be kept up by charcoal than by any other fuel, for its utmoſt intenſity of heat fully equals that of coal or coak, and beſides it affords the great advantage of burning away very ſlowly, with a gentle and pretty ſteady temperature, when the ſupply of air is juſt ſufficient to keep the fire alive. Charcoal (beſides being expenſive) has however the inconvenience of being too light to bear a very ſtrong blaſt of air in common blaſt-furnaces, except it is in larger pieces than is often convenient, and it alſo burns out very rapidly in a ſtrong draught, ſo as to require a conſtant ſupply. There appears to be very little reaſon for preferring the charcoal of one wood over another, provided both are equally well burnt. It may be added that the wood intended for charcoal is always previouſly barked; when this is neglected the charred bark as ſoon as it is kindled burns with a ſhort but prodigious eruption of ſparks, often inconvenient to the operator.

Coal is the fuel almoſt invariably uſed in this country for common culinary purpoſes, for all manufacturing fires where a moderate heat is wanted, and the ſubſtance is not injured by the ſmoke, or can be put out of the reach of it (as in brewers and diſtillers coppers) and in the laboratory for heating ſand-baths, for ſmith's forges, and alſo for the reverberatory furnace. It gives a large, ſtrong, and very laſting flame, but for any intenſity of fire it requires a pretty large and high chimney, and a wide aſh-hole.

Coak gives a very ſtrong heat without flame, and this is the general material for ſtrong wind and blaſt furnaces, where an intenſe and durable heat is required. Coak, in the way it is commonly prepared, always gives out at firſt a blue ſulphureous flame, which ceaſes when fully red-hot. On account of the great denſity of this ſubſtance it bears the blaſt extremely well, but being a much leſs pure combuſtible than charcoal, and containing a mixture of earths and oxyd of iron, it is very apt when nearly burnt out to cake together in an intenſe heat, and to run into a tough coheſive ſlag, quite glaſſy and ſonorous when cold, and which melts on the ſurface of the crucibles, and can hardly be detached from them. Coak alone is not eaſily kindled, and requires a much more powerful draught of air than any other fuel, ſo that it cannot be burned in an open grate except it is in very large quantity. Its combuſtion is materially aſſiſted, and its vitrification when nearly burnt out is much prevented, by mingling it with about its own bulk of charcoal, and theſe two together form the very beſt material for the furnaces that require an intenſe heat.

Coal cinders, picked from a common fire, by removing the coal juſt when it ceaſes to blaze, and before it begins to burn to aſhes, is often preferable to coak for laboratory experiments, as it is of a much lighter and looſer texture, and much leſs ſulphureous, and burns more readily, giving out a very intenſe heat. The beſt Newcaſtle coal, of the kind that ſoftens in the fire and is highly bituminous, gives the beſt cinder for this purpoſe, which, when cold, is gloſſy, light and ſonorous.

A mixture of refuſe coal and charcoal made up into irregular cakes and charred together has been introduced of late years for malthouſes and ſimilar purpoſes where a ſtrong clear heat is required, and this, when broken into ſmall pieces, anſwers extremely well for the laboratory.

Culm or Welſh Coal (which has been deſcribed under the article *Coal*) differs from all the common kinds of coal in burning without any flame or ſmoke, or leaving much reſidue. In this reſpect it more reſembles charcoal, and it has been found to anſwer very well as a fuel for ſmall blaſt-fires; and being much heavier than charcoal, it is not ſo readily diſperſed by the force of the ſtream of air.

Kilkenny Coal is nearly of the ſame nature as culm, but not ſo pure.

Turf ſhould not be unnoticed, though it is ſeldom uſed. It is a uſeful material for lighting fires, and it burns for a long time with a low ſmothering heat, and much pungent ſmoke when the draught of air is very ſmall. It might be employed for long digeſtions with a very gentle warmth, even more effectually than charcoal, and at very ſmall expence, but theſe operations are now chiefly performed by the lamp, which is on the whole to be preferred.

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We ſhall now deſcribe ſome of the furnaces actually employed in the laboratory.

Pl. VIII. Fig. 77 and 78 are a view and ſection of *Dr. Black's Portable Furnace*, as it is called, being, with ſome variations and improvement, that which was invented by that eminent philoſopher. It conſiſts of an oval iron caſe

22 inches high, 20 in its largeſt diameter, and 15 in the ſhorteſt, lined with fire bricks for about three fourths of its height from the top, which forms the body of the furnace, and the firſt elbow of the chimney, whilſt the lower part, which is not lined, forms a very ſpacious aſh-pit. Being very heavy it is put upon caſtors, by which, with the aſſiſtance of the ring handles on the ſide, it may be moved along a floor without difficulty. *a*, *a*, is the body of the furnace, which is cylindrical, but a little oblique, that the flame of the fluel may heat the ſand-bath ſomewhat more equally than if it were a ſtraight cylinder. The breadth of this cylinder is 8½ inches, and its height 15; the grate *c*, lies acroſs the bottom. This fire place has the following ſix openings above the grate. The higheſt is the large opening at the top, which, when a ſand-heat is employed, receives the ſand-bath *i*, and Fig. 82, and when this is not wanted, is covered by a thick iron plate lined with clay, Fig. 80, in the center of which is a ſmall hole fitted with a ſtopper, Fig 81, through which the ſtate of the fire may be ſeen without ſcorching the face. The next opening is the elbow of the chimney, *f*, which widens as ſoon as it takes a perpendicular direction, and for the firſt few inches forms a part of the iron caſe of the whole furnace, and is lined with clay, after which it is elongated by a conical iron chimney, Fig. 79. Even this ſmall length of flue is ſufficient to keep up a very conſiderable heat when the fire is well ſupplied with fuel, but to raiſe it to the intenſity requiſite for melting caſt iron, it is neceſſary to add ſeveral feet of iron pipe of the ſame diameter as the top of Fig. 79. if it is ſet under an open brick chimney, or elſe (which is often more convenient) to cloſe the throat of the brick chimney with an iron plate, leaving only a round hole in the middle, into which the upper part of the pipe, Fig. 79. cloſely fits. In this caſe no further length of iron flue is required to give a very ſtrong draught through the furnace, capable of raiſing heat enough for almoſt any purpoſe of the chemiſt. Oppoſite the chimney hole in the body of the furnace, and a little below it, is the opening *e*, *e*, which ſerves to introduce fuel when the upper opening is engaged by the ſand-bath, and the heat of the latter may alſo be leſſened at pleaſure by leaving this hole open, which cauſes a draught of cold air to ruſh in directly round the bottom of the ſand-bath. The next openings are two ſmall round holes, *g*, *g*, placed directly oppoſite each other at right angles with the perpendicular of the chimney, and ſerving to introduce an earthen or iron tube, the uſe of which will be explained under the article *Hydrogen* (*Apparatus for*). Below theſe is the ſixth opening, *d*, *d*, cut of the proper ſhape to receive a muffle for which it is intended. The openings *e*, *d*, and *g*, are properly fitted with very thick ſtoppers, which are further covered with pieces of iron plate cloſely ſliding in grooves, in the way repreſented in Fig. 77. The aſh-pit is merely the lower part of the iron caſe that incloſes the whole furnace, and is furniſhed with two doors, *b*, *b*, by which the draught of air may be regulated. The rings *h*, *h* (of which there are two correſponding ones on the other ſide) are intended to ſupport upright pieces of thick iron wire, which, with a croſs wire over the top of the furnace, will ſerve to ſuſpend any veſſel or other body over or in the furnace, as may be required.

A great variety of operations, and on a tolerably large ſcale, may be performed in this uſeful furnace, which is very durable, and being heavy and ſubſtantial, it is not liable to be damaged by accidental blows, or eaſily diſplaced; and it is beſides extremely ſafe in a room, provided the chimney is clean. The iron caſe ſhould be now and then rubbed with black lead to prevent its ruſting. This arrangement of the chimney allows very free acceſs to the body of the furnace, and the thickneſs of the walls prevents the operator from being at all moleſted by the intenſeneſs of the heat. It is the leaſt convenient for naked diſtillation from an earthen or iron retort, for though ſuch a veſſel might be ſet on a retort ſtand with its beak projecting through the opening *d*, neither the ſize nor ſhape of this opening are well adapted for this purpoſe, and to give a ſtrong heat, a ſtopper of ſoft brick with a deep ſlanting groove muſt firſt be fitted in.

Fig. 83 and 84, of Pl. VIII. are a view and ſection of a *Muffle Furnace, for very intenſe heat*, employed by Pott, and afterwards by Darcet, in experiments on the habitudes of earths and ſtones in long continued and violent heat. The conſtruction of this furnace is ſimple and obvious; *a*, *a*, is the body of the furnace, in form of an oblong coffer, bulging out in the middle. *c* is the grate ſtanding over the aſh-hole *f*; *e* is the hole for the muffle; *b*, *b*, is the dome or upper piece of the furnace, with a very large door *d*, through which the fuel is introduced. The draught is raiſed by a long perpendicular chimney, Fig. 85.

Pl. II. Fig. 41. is the lower part of a ſmall *Portable Chamber Furnace*, often uſed in the lecture room, and fitted for a great variety of purpoſes. The upper part (which is not here given) is a rounded dome terminated by a perpendicular iron flue.

It is introduced here merely to ſhew the experiment of procuring *hydrogen*, by paſſing ſteam through a heated iron tube, as will be further deſcribed.

The furnace itſelf is a neat iron caſe lined with fire-brick, and furniſhed with openings for a variety of purpoſes.

Pl. IX. Figs. 86, 87, 88, and 89, repreſent a view and ſection of a *Portable Blaſt Furnace*, of ſimple conſtruction and little expence, which was ſuggeſted to the writer of this article from one of Dr. Lewis's, and deſcribed at large in the Philoſophical Magazine, vol. xvii. *a* and *b* Fig. 86 and 87. are portions of two common black lead pots of the ſame diameter, the loweſt of which is inverted, and ſtands upon a ſmooth ſtone, *i*, which is ſupported by an iron trivet about a foot from the ground. The pot, *a*, receives the blaſt of the double bellows as here repreſented, through the hole *h*. The upper part of this pot (or what would be the bottom when uſed as a crucible) being conſiderably thick, will allow of a ſmall hollow to be ſcooped out of its ſubſtance, through which a wide hole muſt be drilled to the cavity below.* By this means the blaſt riſes in a perpendicular direction and equally into the pot *b*, inſtead of ſpending itſelf chiefly on the ſide oppoſite to the bellows, which would be the caſe if the lower pot was not inverted. *b* is the pot which contains the fuel and the crucible or other matter to be heated. It is prepared in the following manner: drill a hole through the bottom with a gimlet as exactly in the center as poſſible, and enlarge it to about the ſize of a ſhilling. This hole is not for the paſſage of air, but to receive a crucible ſtand, *c*, and Fig. 89 in the form of a ſtopper, which keeps it ſteady. Then ſtrike a circle with compaſſes on the ſmoothed bottom of the pot *b*, round the center hole, and bore through it upon the circle at equal diſtances, four or ſix large gimlet holes, in a ſlanting direction, ſo that if lengthened they would all meet nearly in the middle of the pot. No extreme nicety however is neceſſary in the preciſe direction of theſe holes, but the general intention of the oblique direction given them is to concentrate the force of the fire upon the center where the crucible *d* is placed. Theſe two pots are all that is eſſential to the furnace, and when lighted charcoal or cinders are put in and the bellows worked, the blaſt riſing from the lower pot divides itſelf equally through the four or ſix blaſt-holes in the bottom of the upper pot, and very ſpeedily raiſes a very intenſe heat. No luting whatever is required here, the pots are ſimply ground ſmooth with water on any flat ſtone, and when uſed are merely placed in the manner here given. As they are only the lower parts of the large crucibles, the chemiſt may often find what will anſwer his purpoſe from the crucibles that are flawed or otherwiſe damaged. The ſtoppers are made very eaſily out of the ſoft Windſor brick. The bellows are fixed to a heavy ſtool, and their handle is lengthened to work eaſier, but of courſe any other form of double-blaſt bellows will anſwer as well. To protect the eyes from the dazzling heat which is produced in the pot *b*, it is often adviſeable to cover it with the pot *e*, Fig. 88, which has a wooden handle *g*, fixed into it, and an opening for the flame and ſmoke *f*, which may be turned away from the operator.

The black-lead pots are the eaſieſt cut by an old thin table knife deeply hacked or jagged.

Pl. IX. Fig. 90 and 91, is a plate and ſection of the *Reverberatory Furnace*, uſed for roaſting and ſmelting ores both in the large way, and, on a ſmaller ſcale, for experimental purpoſes. In this furnace the ſubſtance to be heated is not in actual contact with the fuel, but is ſtrewed on a ſeparate floor or hearth, placed between the fuel and the chimney, and is heated by the flame in its paſſage through. The floor on which the ore is ſpread is called the laboratory, *d*, and is ſometimes horizontal, but generally on an inclined plane, ſloped from the fire-place to allow the metal when reduced and liquefied to collect and ſettle at the lower end. The floor of the laboratory is formed with ſand mixed with a little clay, and well beaten into a ſmooth compact ſurface, and this is ſometimes further coated with a mixture of charcoal powder and clay. The roof is vaulted, and low, ſo as to allow but a narrow ſpace for the paſſage of the flame, but the preciſe curve to be given it is of little conſequence, provided it is as flat as is conſiſtent with due ſtrength, in order to contract the ſpace between it and the floor. The loweſt part of the floor of the laboratory *e*, is called *the crucible*, and is generally left uncovered when the furnace is charged, as it is intended to receive the melted metal, which, when a ſufficient quantity is collected, is drawn off from time to time through the channel *f*, which is kept plugged up with clay till the moment of caſting. The grate of the fire-place *b*, is fixed a little lower than the level of the adjoining and upper part of the floor of the laboratory. The fuel is thrown in through a ſide-opening *a*, and is of a ſort that produces much flame, ſuch as wood or pit-coal, which therefore muſt traverſe the whole length of the laboratory to reach the chimney *h*. The draught of outer air comes in through the aſh-pit, and often is brought immediately from without, through the channel *i*. The chimney *h*, ſometimes riſes perpendicularly immediately above the crucible *e*, but at other times it leaves the laboratory by a ſide-opening, as here repreſented, which plan is particularly adopted in long ranges of reverberatories for ſmelting in the large way, where one lofty upright chimney ſerves for two furnaces, receiving a lateral flue on each ſide. The laboratory has beſides two ſeparate openings, one at *c*, which is in the ſame line with the door *a*, of the fire-place, and ſerves to introduce the ore; and the other at *g*, which looks along the whole length of the laboratory, and allows the introduction of a kind of iron rake, by which the ſcoriæ are drawn out. This opening has alſo a ſmaller ſight hole in the center of the ſtopper, by which the progreſs of the work may be examined, or an iron bar may be thruſt in to ſtir up the materials. The breadth of the laboratory at its upper part is the ſame as that of the fire-place, but it gradually contracts towards the lower end, that the heat may be concentrated upon the crucible where it is the moſt needed.

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* This ſcooped cavity is however by miſtake repreſented much deeper than the real thickneſs of the pot would allow.

Plate X. is a perſpective view of a very convenient and well contrived ſet of fixed furnaces lately built by Mr. Pepys, at his laboratory in London, whoſe liberality has allowed us to procure a very accurate drawing of the whole, reduced to the ſcale thereto added. Plate XI. contains two repreſentations of the ſame; the ſhaded plan being a ſection on the level of the grates, and the outline plan, a perpendicular view of the furnaces. The letters of reference are the ſame for all. Plate XII. alſo contains certain detached parts which could not be repreſented in the general view.

This ſet of furnaces conſiſts of the following, viz. a ſtill with its worm tub—a forge hearth—a muffle furnace—a ſtrong draught furnace for melting—a furnace for naked diſtillation—a ſquare ſand bath for digeſtions—and a round ſand bath for diſtillation.

There is beſides a ſmall ſpace left on the ſame level as the top of theſe furnaces on which a portable ſtove or black lead furnace may be ſet. The chimnies correſponding with theſe furnaces are five in number, placed ſide by ſide, and proceeding to the top of the building about 20 feet. The face of this ſtack of chimnies projects about a foot and a half into the room, and from it a ſcreen projects, level with the cieling of the room, which hangs down in a ſloping direction to about ſix feet from the floor. Its uſe is to collect and convey away all the ſmoke and fumes which would otherwiſe eſcape into the room. Each of theſe parts requires a fuller deſcription.

A is the *Worm Tub* belonging to a ten-gallon *Still* B, which is of the uſual form, and contains alſo a water-bath. The chimney, C, of the fire beneath the ſtill is arched, and paſſes acroſs the vacant ſpace Q. into the firſt of the upright chimnies into which it opens.

E is the *Forge Hearth*. The blaſt pipe *a* of the bellows (which are moveable at pleaſure) riſes up into the hearth at *b* where the fuel is laid, as in the common ſmith's forge, and the ſmoke is carried off by the moveable iron pipe D, which paſſes up beneath the ſcreen N (part of which is repreſented as broken away to ſhew the courſe of the pipe) and enters the firſt chimney. The hearth contains two ſmall trenches at *d*, in which tongs and pincers may be conveniently ſet.

F is a *Muffle Furnace* of ſimple conſtruction. The muffle is introduced by a ſide ſquare opening at F. Pl. X. The top of this furnace is quite flat, and is covered by a very large thick ſquare brick, incloſed in an iron rim, which ſimply lies upon it. The iron rim ſupports a handle by which the cover may be conveniently removed.

The center of this range is a very powerful *Draught Melting Furnace*. G is the body of the furnace, which is nearly in the form of a double cube. The upper part of it is formed by a bank of brick work, H H. Pl. X. and XI. projecting forward in an inclined plane upon the common level of the top of the whole range of furnaces, and cut down in the center, forming the large ſquare opening at H. Pl. X. which looks down into the body of the furnace. This ſloping direction of the upper opening gives a very convenient acceſs to the fire for adding fuel and managing the crucibles, and the whole opening is cloſed by a thick brick ſimilar to that which covers the muffle furnace. Oppoſite the center of the opening at H, Pl. X. is the chimney of the melting furnace, (repreſented by a very dark ſhading) which goes horizontally for a few inches and then forms the middle-moſt of the five perpendicular chimnies. This is the only chimney the draught of which is never diſturbed by the reception of any other flue. At the lower part of the aſh-pit of this furnace is ſeen a ſquare hole in Pl. X. which opens from behind, and is the termination of the brick canal, *a*. Pl. XI. which runs beneath the floor of the laboratory, and communicates with the outer air at *b b*. The uſe of this is to afford an ample ſupply of air to the furnace from without (and conſequently cooler) which much increaſes its force; and alſo, more particularly, to allow the operator when ſtanding before the furnace, to put a board to intercept the draught from the room to the aſh-pit, which in winter is very troubleſome from the chill which the cold air gives to the legs in ruſhing by. The grate of this, as of all the other furnaces, is not fixed in the brick work, but is ſupported merely by two iron bars a little below the bottom of the body of the furnace, upon which it ſlides in with eaſe, and when worn out or damaged, may be entirely drawn away by the opening of the aſh-pit, and another put in its place. This is particularly uſeful in the melting furnace, as the intenſe heat is very apt to damage and deſtroy the bars of the grate.

I is a furnace for *Naked Diſtillation.* One ſide of it is cut down the middle to admit the beak of an earthen retort, and pieces of thick brick properly hollowed are introduced over and under the beak to fill up the cavity. A perpendicular ſection of this furnace is given in Pl. XII. Fig. 94, which is introduced chiefly as giving the proportions between the body of the furnace, the aſh-pit, and the flues, which will anſwer for all.

K is a *Digeſting Sand Bath,* or ſquare flat-bottomed iron pot, ſet over a ſmall furnace and filled with ſand. On it evaporating pans and any other glaſs veſſel may be conveniently placed, to receive a ſafe and gradual heat. The flame in this inſtance does not immediately proceed from the fuel to the chimney, but is cauſed to paſs again round the iron pan, as in the outline plan K. Pl. XI. The pan is alſo ſhewn in Pl. XII. Fig. 93.

L is a common *Sand Bath Furnace.* Inſtead of the ſand bath a boiler may be ſet over the fire when wanted.

M is a flat ſurface level with the top of all the furnaces, on which any thing may be ſet away, or which will very conveniently ſupport a portable furnace, and for this latter purpoſe a ſide opening is made in the upright chimney, to which it is contiguous, which opens into it, about the ſame height as the flue D, on the oppoſite ſide.

Near the top of the room are two ſquare doors repreſented on each ſide of O, Pl. X. which communicate with each of the upright chimnies next the centre one, and may be opened occaſionally to let out any noxious fumes, or to inſert the pipe of a portable furnace.

The whole of this range of furnaces, as already mentioned, is fronted with a ſolid ſcreen, or kind of awning of maſonry, which ſprings from the cieling contiguous with the wall of the room, and comes down in a ſloping direction ſo far forwards as to project over the front of the furnaces, and as low down as will admit a perſon to ſtand conveniently under the lower margin. This ſcreen, NN, Pl. X. is repreſented as broken away both in front of the upper part of the flue D, and alſo of the upper part of the face of the five perpendicular chimnies, ſo as to ſhew the doors on each ſide of O, which otherwiſe would be hid. All ſmoke and noxious fumes therefore, which eſcape from this part of the laboratory, are caught by the ſcreen, and riſing to the top may readily be carried off by opening one of theſe doors.

Pl. XII. Fig. 92. repreſents the iron door of the ſtill and ſand-bath furnaces, which is double, the inner one being connected to the outer by a hinge, which cauſes it to open and ſhut at the ſame time. The lower door alſo is ſomewhat uncommon in conſtruction, having a circular opening round which revolves an iron plate, partly perforated, ſo as to act as a regiſter.

Fig. 95, 96, 97, 98, are *Fire Tongs* of various conſtruction.

GAS. (*Apparatus for ſaturating fluids with.*)

It is often required in chemical operations to impregnate water or other liquids with one or other of the gaſſes, and a great many ingenious contrivances have been invented for the purpoſe. To effect it compleatly, the liquid muſt be ſo ſituated as to have a quantity of the gas confined with it in a cloſe veſſel, or conſtantly paſſing through it, and the abſorption is always much aſſiſted by artificial preſſure or agitation, or both together.

Some gaſſes, ſuch as carbonic acid gas or ſulphuretted hydrogen, are ſo ſoluble in water that this fluid may be made to take up a conſiderable quantity ſimply by being ſhaken together in a cloſe phial, and therefore for extemporaneous purpoſes, where the waſte of a little of the gas is not an object, nothing more is neceſſary than to fill a common phial quite full of diſtilled water, to invert it in a ſmall tea-cup full of the ſame, to introduce under the mouth the tube of a *proof bottle*, and to throw up as much air as will expell about half the water from the phial; then keeping the finger cloſe upon the mouth of the phial ſhake it very violently for a minute or two, and ſo much of the gas will be abſorbed as to produce a very ſenſible vacuum in the phial. But as large quantities of aerated water cannot be prepared in this way, ſome machine is required to preſent ſucceſſively to the ſame portion of fluid a freſh ſupply of gas, till it is as fully ſaturated as can be done under the degree of preſſure employed.

The machine invented by Dr. Nooth, and known by the name of *Nooth's Apparatus*, has long been in common uſe for this purpoſe, and though it has ſome defects, it is on the whole a very uſeful apparatus. This machine, Pl. III. Fig. 46. conſiſts of three veſſels; the loweſt, *a*, has a very broad flat bottom, that the whole may ſtand ſteadily. It contains the materials from which the gas is given out (marble duſt and dilute muriatic acid for example, when a carbonated liquid is to be prepared, which is moſt commonly the caſe) of which a freſh ſupply is from time to time to be added through the opening made for that purpoſe, the ſtopper of which muſt fit very accurately. The gas paſſes through the valve *b*, into the veſſel *c*, which contains the liquor to be impregnated. A ſection of the valve is repreſented ſeparately in Fig. 45, and conſiſts of a portion of a glaſs tube *b*, open at bottom, and cloſed at top, but perforated with ſeveral ſmall holes, and which fits cloſely into the bottom of the veſſel *a a*, that contains the liquor. The inner part of the tube *b*, is partly filled with two thick pieces of glaſs tube (repreſented by the deeper ſhading) with the ſmall perforations *c* and *e*. The ſpace between theſe two pieces is occupied by a glaſs valve in the form of a plano-convex lens, which lies flat upon the lower piece on which it ſmoothly fits, but is eaſily lifted up by the influx of gas from below, ſufficient to allow it to paſs; whilſt it is ſo far confined that it cannot be turned over, but immediately falls down again in its proper place.

The middle veſſel *c* (Fig. 46) has a glaſs ſtop-cock to draw off the liquor, and into it dips the end of an upper veſſel *d*, which is intended to afford a ſmall preſſure on the gas in *e*, and alſo a conſtant circulation of the liquor from one to the other. At the top of *d* is a ſtopper, which is the only joining of the whole apparatus which is not required to fit very tight, as it is only intended to allow the exceſs of gas to eſcape; and indeed it ſhould fit rather looſely, otherwiſe it allows ſo great a quantity of gas to collect within, that when it is forced up it is often projected to ſome diſtance. A looſe cork anſwers as well. In uſing this apparatus, ſo much liquor ſhould be poured into the middle veſſel as to riſe ſome way above the bottom of the tube of the upper veſſel that dips down. The gas being then generated in the lower veſſel *a*, it riſes through the water of *c*, up to the juncture between *c* and *d*, where, not being able to eſcape, it accumulates, and by its preſſure cauſes the liquor to flow through the bent tube into *d*, driving before it the atmoſpherical air. When the liquor has thus fallen in *c*, below the level of the dip of the bent tube, the gas riſes through this tube, and in its paſſage agitates the liquor in *d*, and ſends down a portion; and thus a conſtant agitation is kept up which highly favours the abſorption.

The chief inconvenience of this machine is the number of parts of which it is formed, and the accurate grinding required for all the pieces that fit, which makes the apparatus expenſive, and not eaſily repaired when any portion is broken.

A much ſimpler, cheaper, and equally good apparatus is that repreſented in Pl. III. Fig. 47. invented by the late Dr. Hamilton. It conſiſts of three parts. *a* is a tubulated retort, with a ſhort thick neck, fitting accurately into the decanter-ſhaped veſſel *b*. The retort contains the ſubſtances whence the gas is procured, and has the advantage over Nooth's apparatus, in allowing heat to be applied, ſo that it will ſerve for making liquid oxy-muriatic acid, and for many other purpoſes.

The upper veſſel *c* fits into the decanter, and beſides has a long glaſs tube proceeding from the bottom, and ground accurately to it, which reaches to the bottom of *b*. The veſſel *c* ſhould hold about as much as the decanter. The uſe of this apparatus is obvious. The decanter is firſt filled with the water to be ſaturated nearly as high as the point where the retort enters, and the advantage of the decanter-form is that very little common air is then left in. The influx of gas from the retort accumulating at the top of *b* drives the contained liquor up the tube *d*, into the veſſel *c*, till the decanter is quite empty of water, and only filled with the gas, on which a conſiderable preſſure is therefore always kept up.

This apparatus is not readily deranged, its parts are ſtrong and ſimple, and it will bear as much ſhaking as Nooth's machine, care being taken to keep the retort itſelf as ſtill as poſſible, that none of its contents mix with thoſe of the decanter.

Another apparatus, ſimilar to Dr. Nooth's, but ſomewhat better, is formed by the veſſels *a*, *b* and *d* of Fig. 42, adding to the top of *d* the veſſel *a* of Fig. 44. A valve is placed between *b* and *d* ſimilar to that of Nooth's apparatus. But as theſe veſſels alſo belong to an improved *Woulfe's Apparatus*, we ſhall mention them under that article.

It ſhould be obſerved however that the utmoſt effect of the beſt glaſs veſſels in impregnating water with carbonic acid, or any other gas, is very far ſhort of the power of the forcing pump; and it is by this latter method that all the briſk foaming carbonated waters are made which are conſumed ſo largely under the names of artificial Seltzer, Soda, Pyrmont waters, &c. Mr. Paul, of Geneva, appears to have been the firſt who adopted this excellent method of making the artificial mineral waters.

GAZOMETER.

Theſe are veſſels of various ſhapes and contrivance, intended as reſervoirs to hold a pretty large quantity of gas (ſeveral gallons for example) and are indiſpenſible in a well-furniſhed laboratory. They are made of thin tinned iron-plate, well japanned on both ſides, and moſt of them have ſome contrivance for meaſuring the quantity of gas which they contain. We ſhall deſcribe three kinds of gazometer, all of which are in common uſe and anſwer very well.

Pl. V. Fig. 61 and 62 repreſent a view and ſection of a common gazometer. The letters in each refer to the ſame parts. *a a* is the outer pail or circular veſſel, with a ſpout at top. Two tubes *d* and *e* (each fitted with a ſtop-cock externally) are firmly ſoldered to the ſides of the pail: the tube *d* penetrates at the bottom of the pail and proceeds to the center where it joins the termination of the tube *e*, which enters the top of the pail and proceeds downwards; and from the place of junction the upright tube *g* riſes through the middle of the pail a little above the level of its upper rim. The veſſel *b* is a cylinder open only at the bottom, and of leſs diameter than the pail, into which it is inverted, and can move up and down freely. This cylinder has a ſolid ſtem *c*, which paſſes through a hole in the wooden croſs bar of the frame round the top of the pail, and ſerves both to keep the cylinder in a perpendicular direction when moving up and down, and to indicate the quantity of incloſed gas by the graduation on its ſurface. The weight of the cylinder is counterpoiſed by weights put in a ſcale diſh, which is connected to the top of the cylinder by a cord and pulley. The pail has beſides an opening through its bottom cloſed by a ſeparate ſtop-cock *f*, by which the water may be drawn off. The whole apparatus is conveniently ſupported on a heavy wooden ſtool. It is not eſſential to have both the tubes *e* and *d* for the filling and emptying of the gazometer, but it is more convenient, as they are of different heights. To uſe this gazometer, firſt let the cylinder fall to the bottom of the pail, and pour water into the ſpout of the latter till it is quite full. Then ſhut the cock *e* and open *d* and connect with it the tube which conveys the gas immediately from the retort or other veſſel in which it is produced; or, if more convenient, ſhut *d* and convey the gas through *e*. In either caſe the gas riſes through the upright tube *g* to the top of the cylinder *b*, which it gradually lifts up, and care muſt be taken to keep in the ſcale diſh ſufficient weight to allow the cylinder to move with perfect freedom. When all the gas is obtained, ſhut the cock through which it paſſed, and it remains in the inverted cylinder ready for uſe. To take out a portion of it, connect with either of the ſtop-cocks a bent-tube dipping under the jar, or whatever veſſel it is to be received in inverted over water, and at the ſame time lift up the ſcale diſh, on which the cylinder will preſs down by its own weight, and force out the contained air. The tube which terminates at *e* is a very convenient height for a blow-pipe, either for common air or eſpecially for oxygen gas, and ſtraight blow-pipe tubes are made for the purpoſe, which may be of the ſize to fit on cloſely, or may eaſily be made to do ſo, by the intervention of a cork. It ſhould be obſerved that in this apparatus the weight of the cylinder is conſtantly increaſing in proportion as it fills with gas, and riſes out of the water, and conſequently if the counterpoiſing weight is only equal to that of the cylinder in the firſt moment of its riſe, the gas becomes gradually more and more compreſſed by that part of the weight of the cylinder which is not counterpoiſed, and if its quantity is then eſtimated by the bulk which it occupies, without making allowance for the increaſing preſſure, a material error would ariſe. To compenſate for this increaſing weight of the cylinder, and render a ſcale of equal graduations accurate, ſome have ingeniouſly adopted the plan of a ſpiral pulley to the cord, which has the effect of gradually increaſing the weight of the counterpoiſe in proportion as the cylinder riſes from the water.

Fig. 63 is a gazometer on the ſame principle as Fig. 61 & 2, and differing from it only in this ſingle circumſtance, viz. that the outer pail has the greater part of its capacity filled by a hollow cylinder h. h. which is cloſed on all ſides except a perforation through its center to admit the upright air-tube *g*, and is firmly ſoldered to the bottom of the pail. The uſe of this fixed cylinder *h* is to leſſen the bulk of water neceſſary to confine the gas in the moveable cylinder *b*, and which in the firſt deſcribed gazometer is often inconvenient from its weight, as it fills the entire capacity of the pail except the ſmall ſpace occupied by the mere ſubſtance of that part of the cylinder *b* which is immerſed. Whereas in Fig. 63 the quantity of water required is only that which will fill the ſpace *a a* between the pail and the fixed cylinder *h. h.* in which ſpace the gas-cylinder *b* moves up and down freely. The vaulted form of the upper part of this latter cylinder is alſo an improvement, as it admits of the air remaining in it being more completely emptied by the pipe *g* before a freſh diſtillation of gas is begun.

Plate. VI. Fig. 64 is a very ingenious and uſeful gas-holder, with a ciſtern at the upper part, which on the whole combines more conveniences in the management of gaſſes than any other. It conſiſts of a tinned iron hollow cylinder *a* highly japanned, on the top of which is ſupported by three ſolid legs *h. h.* the pan or ciſtern *b.* (the glaſs jar *c* is not a part of this apparatus, but is only ſhewn in this place as convenient for many experiments). The hollow cylinder *a* is plain in the inſide, except a ſmall projection at the bottom of *d*. It has the following ſix openings into it. From the top proceed the pipes *f* & *g*, each of which alſo communicates ſeparately with the pan *b.* (the tube *g* is often made parallel with *f*, which anſwers as well.) The ſhort tube *e* alſo opens directly into the upper part of the cylinder. *d* is a pretty large opening formed by a ſhort pipe which enters the cylinder at an angle of about 45°. and paſſes down for an inch or two in the ſame direction. At this angle the water will not run out through it from the cylinder, provided all the tubes that would admit the preſſure of the external air are cloſed. This opening *d*, has a ſtopper which may be ſcrewed on when wanted. Beſides theſe four openings, which are eſſential to the apparatus, there are two others, *k. k.* one at top and the other at bottom that communicate ſolely with the graduated glaſs tube *i*, which is ſtrongly ſoldered into *k. k*, which are of braſs. The uſe of this is to ſhew by inſpection of the glaſs tube the level of the water within the cylinder, and conſequently the quantity of gas which it contains. The uſual capacity of the cylinder for experimental purpoſes is about 12 quarts, which are marked on a paper ſcale cemented to one ſide of the glaſs tube.

To fill this apparatus, firſt ſtop the openings *d* and *e*, and open *f* and *g*, then pour water into the pan *b*, which will fall down into the cylinder by one of the open tubes, whilſt the air which it contained will eſcape by the other. When the cylinder *a* is quite full of water, which is known by inſpecting the glaſs tube, ſtop the cocks at *f* and *g*, and open *d*, and the water (as already mentioned) will not flow out. Then introduce the beak of the retort or other conducting tube, ſo deep into *d*, that it projects beyond the inner edge, and begin the production of the gas. As this riſes into *a*, it diſplaces an equal quantity of water, which *now* eſcapes through *d*, by the ſide of the tube that brings the gas. When the gazometer is ſo full that the level of the water falls to the bottom of the glaſs ſcale, ſhut the tube *d*, and the machine may then be conveyed any where without danger of loſing any of the gas.

This apparatus will anſwer a variety of purpoſes. If, for example, a jar or any other veſſel is to be filled with the gas, firſt fill the jar with water and invert it in the pan *b*, which is alſo to be filled. Then open the cocks at *f* and *g*, and the gas will riſe into the jar by one tube and the water ſink into the cylinder by another. An empty bladder may be filled with the gas in the ſame manner by ſcrewing or otherwiſe faſtening the neck upon one opening and letting water fall down the other; or it may be more conveniently faſtened to the ſide opening *e*, and then only one of the upper cocks muſt be opened to let water down. The opening *e*, is alſo very convenient for ſupplying a blow-pipe, and for this purpoſe the flexible tube Fig. 68 may be faſtened upon *e*. The glaſs veſſel *c* furniſhes a convenient method of ſhewthe the deflagration of iron, phoſphorus, &c. in oxygen gas without riſk to the veſſel. It is quite open at the bottom, and has an opening of moderate ſize at the top, to which is fitted a cork furniſhed with a ſtop-cock. To fill it with oxygen from the gazometer, firſt place it on the pan full of water, *b*, and through the ſtop-cock ſuck up the air till the water riſes, and fills it entirely, and then turn the cock while the lips are ſtill upon it. The jar is thus filled with water, after which the oxygen is let up by opening the cocks *f* & *g* as already deſcribed. Then remove the ſtop-cock cork and immediately ſubſtitute another cork previouſly fitted to the jar, and having the lighted iron wire ſuſpended from it. The moment it is in the jar of oxygen, the iron takes fire and burns with the phenomena deſcribed under that metal.

It may be obſerved that as the only intention of the ſtop-cock in the cork is to enable the jar to be filled with water, any other method of doing this will anſwer as well.

GUN-BARREL APPARATUS. This term is given by ſome to the following.

HYDROGEN, *Apparatus for procuring.*

Under the article Hydrogen we have mentioned that it is obtained in abundance by paſſing the ſteam of water over red-hot iron, and an ingenious apparatus for the purpoſe was invented by Dr. Prieſtley, which has been ſince applied to a number of other experiments of reſearch, where the object has been to ſend any kind of vapour through a tube containing any ſubſtance heated red-hot. The apparatus is ſimply the following: Pl. II. Fig. 41. *a* is a retort, the beak of which is luted into one end of the tube *b b*, which lies acroſs a portable furnace in ſuch a manner that the middle part may be heated red-hot, whilſt each extremity is comparatively cool. *c* is a bent tube luted to the other end of *b*, and which may be directed under an inverted jar in a pneumatic trough, or any other veſſel intended for the reception of gaſſes. The middle of the tube *b*, which lies over the furnace, is filled with iron wire or turnings cloſely rammed. When this part of the tube is fully red-hot the water in the retort *a* is made to boil, by putting a lamp beneath it, and the ſteam paſſing over the heated iron is decompoſed, and the hydrogen produced by this method is given out copiouſly at the bent tube *c*. In this experiment the tube *b* is generally a plain iron pipe, formed out of a gun-barrel, by filing off the breech. In ſome caſes the tube may be of earth, but it ſhould be remembered that even the cloſeſt pottery is ſomewhat porous at a red-heat, ſo that it ſhould be incloſed in another tube of green glaſs or metal.

A gun-barrel tube for the ſame purpoſe is ſeen at *g*, Fig. 77. Pl. VIII. traverſing a Black's furnace, and is mentioned under the article furnace. Where the ſubſtance to be heated in the tube is of a kind that will not keep its place, as cloſely rammed iron wire will, the charge may be confined by a pellet of wet clay at each end, which as it dries ſhrinks and cracks ſo as to allow the paſſage of aqueous vapour and gas through it, but confines ſolid or pulverulent bodies.

HYDROMETER. See Specific Gravity.

JAR.

Glaſs jars of a cylindrical ſhape or nearly ſo, are indiſpenſably neceſſary in the laboratory, both for experiments on gaſſes, and for holding liquors in all the common operations of filtering, precipitation, mixture, &c. For the gaſſes, the jars are uſually plain cylinders, Fig. 16. Pl. I. of various length and capacity, which ſtand ſteadily enough when inverted over water, and the margin of the open end is generally ground ſmooth, that when any flat plate, or a circular bit of card, is preſſed upon it, the water may not drop out when the jar is inverted. For experiments with mercury, the jars ſhould be ſmaller and thicker, and to ſtand very ſteadily, jars are ſometimes wider at bottom, as in Fig. 18. The moſt convenient jars for mixtures and precipitation are ſuch as Fig. 19, or as thoſe which are repreſented ſtanding under the four funnels in Fig. 65. Pl. VI. theſe being broad at bottom, any precipitate can be more thoroughly edulcorated than in any veſſel of the wine-glaſs ſhape. The thick jar for exploſions with the electric ſpark, ſuch as in Fig. 67, has been already deſcribed under the article *Detonating Jar.*

LABORATORY.

A convenient well-furniſhed laboratory is, of courſe, a principal object with the chemiſt, though it may be ſome ſatisfaction for the lover of this attractive ſcience, whoſe means of indulging it are very limited, to know that moſt of the admirable reſearches of Scheele, Prieſtley, Crawford, and Berthollet, were carried on with ſuch ſimple and cheap apparatus as moſt perſons can command. Nevertheleſs it is of extreme advantage to have a well-furniſhed laboratory; accurate (and therefore expenſive) inſtruments are almoſt indiſpenſible in many experiments of reſearch; and if we have ſimplified many of the long and embarraſſing proceſſes of the older chemiſts, we have, on the other hand, added moſt abundantly to the field of chemical enquiry by the knowledge of gaſſeous bodies, and equally to the number of inſtruments now neceſſary to carry on chemical reſearches.

It may not be unacceptable to thoſe who are entering upon chemical ſtudies, to give a ſhort liſt of thoſe articles of furniture which may be onſidered as almoſt indiſpenſible to carry on a eneral courſe of experiments, omitting however ſeveral nice and complicated inſtruments, which have been deviſed for many experiments of reſearch, ſuch as, for example, the compoſition of water.

If the chemiſt has opportunity of building a laboratory, or of converting a conſiderable part of a ſmall houſe to the purpoſe, it will be more convenient to have both a ground floor and an upper ſtory; on the ground floor he may build his brick furnaces, keep charcoal and other fuel, grind and ſift different materials, evaporate large quantities, and do all thoſe things which make much duſt or fumes, and reſerve the upper room for the nicer and cleaner experiments. But if he can only devote a ſingle room to chemical uſes, it is on the whole preferable to have it above the level of the ground, on account of its being much drier, for a damp air ruſts every thing of iron and ſteel, ſpoils the ſcale-beams, looſens the gummed labels to the bottles, renders many ſalts damp and deliqueſcent, and produces many other inconveniences. The only advantage of a ground floor is the greater convenience of bringing water (which is abundantly required) but this is not at all counterbalanced by the trouble of dampneſs.

The firſt object to be conſidered is the mode of applying heat, or the ſelection of furnaces. If the chemiſt has only a ſingle room with a common fire-place, the latter ſhould be made as wide as poſſible, and the grate removed to give room for one or two portable furnaces. Theſe may be a *Black's Furnace* with ſand-bath, earthen tube, muffle and other appurtenances, and a *ſmall Blaſt*, which will ſuffice for moſt operations, beſides which it is extremely convenient to have one or two large black lead pots with a grate near the bottom, an aſh-hole cut below it, and the top deeply indented in the form of battlements, over which a large evaporating pan or other veſſel may be ſet, and heated by charcoal. It is a great ſaving of room to have an iron flue hanging a few feet from the ground, and running up in front of the chimney-piece, and penetrating into the chimney near the top of the room, under which a ſmall chamber furnace or a charcoal pot may be ſet, without encumbering the fire-place. The chimney of the Black's furnace ſhould be lengthened by an iron pipe of at leaſt 6 or 8 feet long, and fixed up in the chimney of the room by iron cramps, which increaſes its draught prodigiouſly.

The room ſhould be amply furniſhed with ſhelves for bottles and glaſs apparatus, and with as many or as large deal tables as can conveniently ſtand in it, one of which ſhould be ſubſtantial and heavy, or elſe a kitchen dreſſer may be put up, with drawers below. A ſmall ſet of drawers ſuch as apothecaries uſe, will be highly convenient. If poſſible, a ſtone ſink ſhould be placed at one corner of the room with a ſupply of clear water, and conveniences for waſhing and draining bottles, &c. A ſolid block of wood is alſo uſeful, for ſupporting a mortar when pounding hard ſubſtances, and in which an iron anvil may be ſtuck when wanted.

Theſe being arranged, the chemiſt muſt furniſh himſelf with the moſt uſeful apparatus, of which the following are the principal articles: the deſcription of each individual article with the kind to be preferred, will be found under their reſpective heads:

A gazometer, with the connecting tubes, blow-pipe, &c.

A bladder, or ſilk bag, with ſtop-cock fitting the above.

A pneumatic water trough.

A copper ſtill with worm-tub, the ſtill fitting into the top of the Black's furnace.

A blow-pipe, with ſpoon, &c.

Lamps—an Argand, and others of common conſtruction for oil and alcohol.

An apparatus for drying precipitates by ſteam.

Scales and weights.

Large and ſmall iron ſtands for retorts, &c.

Mortars—one of hard ſteel, one of bell-metal, and one or two of Wedgewood ware.

A ſilver crucible and ſpatula.

A platina crucible and ſpatula.

A jointed iron tube for conveying gaſſes.

The following articles in glaſs:

Retorts of different ſizes, plain and ſtoppered, and long-necked for gaſſes.

Receivers to fit the above, plain and ſtoppered, with or without an adopter.

Plain jars for gaſſes, different ſizes.

Lipped jars for mixtures, precipitates, &c.

A graduated eudiometer jar.

Bell receivers, two or three ſizes.

Proof bottles.

Capſules or ſmall evaporating cups.

Water glaſſes (ſuch as are uſed at table) which are very convenient for gentle evaporations.

Florence flaſks.

Matraſſes—two or three very ſmall, and others of common ſize, round and flat-bottomed.

Funnels—ribbed, and one plain with a very long neck for charging retorts.

Wine-glaſſes—common or lipped.

Watch-glaſſes, for evaporating minute quantities at a very gentle heat.

Common decanters.

A bottle for ſpecific gravity of fluids.

Phials of all ſizes, plain and with ground ſtoppers.

Plain glaſs tube of various thickneſs and bore, out of which may eaſily be made

Syphon tubes.
Bent tubes for gaſſes.
Capillary tubes, for dropping liquids, and various other uſeful articles.

A gas-ſaturating apparatus.

A Woulfe's apparatus.

A tube of ſafety, ſeparate (Fig. 60).

A barometer.

Thermometers—common, and with the bulb naked, to dip into liquors.

The following in Earthen-ware:

Crucibles—Heſſian, common, and black-lead, of different ſizes and ſhapes, with ſtands and covers.

Retorts.

Retort-ſtands (ſuch as Fig. 25 inverted).

Cupels.

Wedgewood evaporating diſhes—a ſet.

White baſons with lips, different ſizes.

Common white cups and ſaucers.

Tubes—ſtraight and bent.

Porcelain ſpoons.

Ditto rods, for ſtirring corroſive fluids.

Several ſtone ware jars with tin covers, for holding ſalts, &c.

Alſo the following ſundries:

Wire—different ſizes and kinds, viz. iron, copper, braſs, ſilver, and platina.

Gold, ſilver, and braſs leaf—tinfoil.

Wooden tripod ſtands for receivers, &c.

Fire tongs—various ſhapes.

Steel ſpatula and pallet knives.

Iron ladles

Diamond for ſcratching glaſs.

Files—flat, three-cornered, and rat-tailed.

Hammers.

A vice and anvil.

Pincers.

Shears and ſciſſars.

A magnet.

Sieves.

Filtering paper.

Corks.

Bladders—ſpirit varniſh—ſponge—tow—linen—flannel.

Windſor and common bricks—tiles—ſand.

Lutes of various kinds. (See article Cements.

For more extenſive and delicate reſearches it it is alſo neceſſary to have

A mercurial pneumatic trough.

A mercurial gazometer.

A burning lens of conſiderable power.

An electrical apparatus.

A Galvanic apparatus.

A Detonating jar.

A glaſs or ſilver alembic.

The fuel to be employed has been already mentioned under the article Furnace, and a ſupply ſhould be kept near at hand, broken down ready for uſe.

With regard to the different ſubſtances or reagents to be kept, the chemiſt will, of courſe, wiſh to have a ſpecimen of all the ſimple or individual ſubſtances, ſuch as the acids, earths, metals, &c. but it may not be unacceptable to add a liſt of thoſe ſimple and compound ſubſtances which are of general uſe, and which therefore ought alſo to ſtand on the ſhelves.

For many purpoſes the ordinary degree of purity in which theſe ſubſtances are obtained by the common proceſſes is ſufficient; ſo, for example, the ſmall quantity of potaſh in common ſulphuric acid, and of iron in common muriatic acid, ſeldom interferes with any of the uſes to which thoſe reagents are applied; but it is alſo neceſſary frequently to have them in the utmoſt purity when employed as teſts for delicate purpoſes. The chemiſt will therefore find it of advantage to reſerve a ſeparate ſet of a few of the moſt neceſſary reagents in their utmoſt purity, and if only employed when abſolutely requiſite, a very moderate quantity will ſuffice. In the ſubjoined liſt we have diſtinguiſhed by the word *pure* thoſe ſubſtances which require particular pains to be obtained abſolutely pure, and the methods of doing it will be found under the reſpective articles. Mixtures of each of the ſtronger acids and water in two or three different and known proportions ſhould alſo be kept.

(N. B. *The letter* D *implies that the Dry ſubſtance ſhould be kept, and* S, *that it ſhould be in Solution.)*

Sulphuric acid,	pure
Ditto	common
Nitric acid,	pure and boiled
Ditto	common and boiled
Ditto	fuming
Muriatic acid,	pure
Ditto	common.

Oxymuriatic Acid
(This ſhould be kept in the dark).
Phoſphoric Acid, pure, from Phoſphorus. S.
Acetic Acid
Diſtilled Vinegar
Ditto, concentrated by froſt
Oxalic Acid. S.
Tartareous Acid. S.
Sulphat of Potaſh. D. & S.
———— Soda. D. & S.
———— Barytes. D.
———— Alumine. S.
———— Strontian. D.
Alum. D. & S.
Nitrat of Potaſh. D. & S.
——— Ammonia. D.
——— Barytes. S.
——— Strontian. S.
Muriat of Soda. D. & S.
———— Ammonia. D. & S.
———— Strontian. S.
———— Barytes. S.
———— Lime. D. & S.
———— Alumine. S.
Oxymuriat of Potaſh. D.
Phoſphat of Soda. D. & S.
————— Ammonia. D.
Acetite of Barytes. S.
———— Alumine. S.
Oxalat of Ammonia. S.
Cream of Tartar. D.
Crude Tartar. D.
Tincture of Galls
Borax. D. & S.
Ditto, vitrified
Fluat of Ammonia. S.
Succinat of Ammonia. S.
Pruſſiat of Potaſh, pure and dry
(This ſhould be kept in the dark)
Pruſſiat of Lime. S.
Plaſter of Paris
White Marble
Bone-Aſh
Fluor Spar
Potaſh, pure. S.
Ditto, common cauſtic. S.
Pearlaſh. D. & S.
Salt of Tartar. D. & S.
Super-Carbonat of Potaſh. D.
Carbonat of Soda. D. & S.
Ditto fully dried
Ammonia, pure
Carbonat of Ammonia. D. & S.
Super-Carbonat of ditto. D.
Lime
Lime-water
Barytic-water
Strontian-water
Carbonat of Magneſia
Hydro-ſulphuretted Water
Hydro-ſulphuret of Soda. S.
———————— Ammonia. S.
Sulphuret of Potaſh. D.
White Arſenic. D. & S.
Manganeſe, Black Oxyd of
Mercury
Ditto, Red Oxyd of
Nitrat of Mercury. S.
Corroſive Muriat of ditto. D. & S.
Zinc, in ſticks and granulated
Tin ditto ditto
Muriat of Tin
Lead
Minium and Litharge
Nitrat of Lead. S.
Acetite of ditto. S.
Iron, Filings, Turnings, Wire
Sulphuret of Iron for Sulphuretted Hyd. Gas
Sulphat of Iron. D. & S.
Ditto, ſaturated with nitrous Gas
Muriat of Iron
Copper, Sheet, Wire
Nitrat of Copper. D. & S.
Silver, Leaf and Wire
Nitrat of Silver. S.
Sulphat of ditto. S.
Acetite of ditto. S.
Gold-leaf
Nitro-muriat of Gold
———————— Platina
Sulphur
Phoſphorus
Alcohol, concentrated and common
Sulphuric Ether
Litmus Tincture
Turmeric
Brazil Wood
Gall Nut
Catechu
Iſinglaſs
Olive Oil
Linſeed Oil, Drying
Oil of Turpentine
Black Flux
Diſtilled Water, in great plenty.

LAMPS. A lamp is a moſt convenient article of chemical apparatus for moderate heat, on account of the ſteadineſs and durability of the heat which it gives; and a vaſt number of experiments may be performed by it. The Argand lamp well trimmed will bring to a boiling heat a pint or two of liquid in a glaſs or metallic veſſel, and may therefore be uſed for numerous diſtillations, particularly in thoſe caſes where the reſt of the apparatus is required to be kept cool. To increaſe the heat of this lamp ſome ingenious artiſts have invented double concentric wicks, which renders it equal to a ſand-heat; but the ſupports of the wicks are apt to be out of order, owing to the fuſion of the ſolder. Smaller lamps are alſo required, and for theſe, alcohol is a very valuable fuel, as its flame is perfectly clean.

MATRASS. This is a thin glaſs veſſel of the ſhape of a flaſk, which will bear a lamp-heat at bottom without breaking. It is either round at the bottom as in Fig. 57. *a*. or flattened a little. Fig. 48. Fig. 18. Pl. I. is a very uſeful ſmall matraſs of about 2 ounces capacity.

MORTAR. This is a moſt eſſential article in a laboratory, to reduce to powder a variety of ſubſtances, and the material of which it is made is of conſiderable conſequence. Very hard bodies, ſuch as the gems, quartz-cryſtal, &c. can only be ground to powder in a mortar of agate, or flint, or ſome other hard ſiliceous ſtone. They muſt previouſly however be cruſhed into fragments, either in a ſteel mortar, or wrapped up in many folds of ſtrong paper, and bruiſed on an anvil with a heavy hammer. The fragments are then collected, and put into the flint mortar with a little water, and a very long continued friction is required to bring it to an impalpable powder. It ſhould always be remembered that when a very hard body is ground to powder, the friction wears the mortar as well as the ſubſtance pulverized, conſequently for delicate experiments it is neceſſary to weigh the mortar before and after the proceſs, and allow for the loſs of weight by an equivalent addition to the powder obtained. Hence too the compoſition of the mortar itſelf ſhould previouſly be known, and by the analyſis of Klaproth it appears that black flint and agate are ſo nearly pure ſilex, that the minute quantity of their other conſtituent parts may be entirely neglected.

For grinding ſubſtances of moderate hardneſs, ſteel mortars with very ſmooth peſtles of the ſame materials, are kept in ſome of the ſhops. Very uſeful mortars are alſo made of caſt iron, which are very hard, but are not finiſhed quite ſo ſmooth as thoſe of ſteel Large mortars of this kind are uſed by the druggiſts for pounding barks, woods, &c. and to leſſen the manual labour, the peſtle is faſtened to the end of a flexible wooden pole, which hangs over the mortar, by the elaſticity of which the peſtle is lifted up again to the proper height after the ſtroke is made. For lighter purpoſes very good mortars are made of bell-metal, with peſtles either of the ſame or of iron. Theſe are caſt very ſmooth ſo that the material to be pounded does not ſtick to the ſides. Moſt neutral ſalts may be conveniently pulverized in them, but their chemical action on the copper ought to be kept in mind, as (for example) if ſal-ammoniac is left for ſome hours in a bell-metal mortar it becomes green by the oxyd of copper which it diſſolves. Theſe mortars are often fitted with wooden covers, perforated to admit the peſtle, ſo as to prevent fragments from flying out by the ſtroke.

Mortars are alſo made of marble, glaſs, and Wedgwood ware. The latter are highly uſeful, being very hard, ſmooth, and not acted on by any chemical reagent. They will readily break, however, by a ſmart blow.

MUFFLE. Pl. I. Fig. 30. A muffle is a vaulted flat-bottomed earthen veſſel, intended to be put in the midſt of a furnace, of proper conſtruction, ſo as to afford a ſpace ſtrongly heated, but protected from the actual contact of the fuel, in which ſmall veſſels of any kind may be ſet. The muffle is entirely open at one end, and cloſed at the other, and it has ſometimes ſmall ſide ſlits, to allow the freer acceſs of the hot air. It is always ſet in a furnace with the open end directly oppoſite a ſide door, of the ſame arched ſhape, and which it touches, ſo as to prevent any of the fuel from getting in.

The door for this purpoſe is ſeen in Pl. VIII. Fig. 77. & 78. *d*. and Fig. 83. *e*. The muffle will juſt ſlide in and out of theſe openings with eaſe, and iron bars or ſome other kind of ſupport are placed in the furnace to keep it at the proper level. When the ſubſtance in the muffle is to be heated without acceſs of air the ſtopper of the furnace may be thruſt in upon it; but when a current of heated air from without is wanted to paſs through the muffle, which is the caſe in aſſaying, the ſtopper of the furnace muſt be removed, and inſtead of it a ſmall iron plate (like the flat part of a ſhovel with the edges a little turned up) is fixed on a level with the bottom of the opening, on which are heaped a number of long pieces of charcoal to block it up. Theſe preſently kindle by the heat of the furnace, ſo that the air which paſſes freely between them into the muffle is heated in its paſſage, and the muffle may be cooled at pleaſure by taking away ſome of the pieces of charcoal. The ſmall crucibles uſed for aſſaying, are called *Cupels.* Fig. 28. & 29.

NOOTH's APPARATUS. See *Gas ſaturating Apparatus.*

OXYGEN *Combuſtion* in. A veſſel very convenient for this purpoſe is ſhewn in Fig. 64. *c.* and is deſcribed under the article *Gazometer.*

PELICAN. Pl. II. Fig. 38. This is an old inſtrument now little uſed, intended for long digeſtions on a ſand-bath, or other heat, with a contrivance for conſtantly returning on the materials at the bottom all the liquid of the menſtruum which would otherwiſe evaporate by the heat. It is therefore a glaſs alembic, in which there are two pipes that collect the diſtilled liquor, and again enter the lower veſſel. The ſmall apparatus at Fig. 37. is for the ſame purpoſe, and is more convenient. Its conſtruction is obvious.

PNEUMATIC TROUGH. See TROUGH. *Pneumatic.*

PRECIPITATING GLASS. Pl. I. Fig. 20. This is a very tall jar with a narrower part at the bottom, in which any precipitate when produced may collect by ſubſidence, and allow of the ſupernatant liquor to be decanted off with more eaſe. It is alſo a very uſeful glaſs in which to float the *Hydrometer.*

PROOF-BOTTLE. Pl. I. Fig. 13. 14. 15. This is a glaſs phial for procuring gaſſes, made thin and round at bottom, ſo as to bear moderate heat, and with a bent tube cloſely ground to it for conveying the gas under any inverted veſſel. It has beſides ſometimes another opening ſolely for introducing the materials. This veſſel is very uſeful for experimental purpoſes, where only moderately ſmall quantities of gaſſes are wanted, and from materials that require no greater heat than a ſmall ſpirit lamp or candle will produce. It is an improvement on the original cheap apparatus of Dr. Prieſtley, namely, a phial with a piece of bent glaſs tube thruſt through the cork and properly cemented. This latter however will often anſwer every end, eſpecially where no artificial heat is wanted, as in obtaining hydrogen from muriatic acid and zinc. It may be uſeful to mention, that corks are moſt conveniently perforated, and the hole made very ſmooth and neat, by the *rat-tailed file.* The joining of the tube and the cork may be made quite air-tight by ſealing-wax.

PYROMETER. (*Wedgwood's*). See the article *Pyrometer* in the former part of this work.

RECEIVER, is a globe-ſhaped veſſel, either plain or tubulated, uſed in the proceſs of *diſtillation.* It receives the beak of the retort, or the adopter, if this is uſed. See Pl. I. Fig. 4. Pl. III. Fig. 42. *b.* Pl. IV. Fig. 59. *d.*

RECIPIENT, *Italian*, is a veſſel like a teapot, intended for the ſeparation of eſſential oils from the watery liquor on which they float.

REFRIGERATORY is that part of a *Diſtilling* Apparatus when the vapour is cooled and condenſed. In the *Alembic* it is at the top of the apparatus; in the common Still it is the Worm-tub. See *Diſtilling Apparatus.*

RETORT is the common and moſt uſeful inſtrument for *Diſtillation.* See Pl. I. Fig. 2, 5, 11. Retorts with very long narrow necks Fig. 1. are made for heating thoſe ſubſtances which are intended to yield any of the gaſſes, for here no width of veſſel is wanted for the condenſation of vapours, and the narrowneſs of the neck allows but little admixture of the external air. Retorts are made of glaſs, earthen-ware, and ſometimes of iron or ſilver. A leaden retort is uſed for procuring fluoric acid.

REVERBERATORY FURNACE. See FURNACE.

SAND-BATH. See BATH.

SERPENTINE or WORM. See DISTILLING APPARATUS.

SOLAR HEAT. (*Apparatus for*). A very elegant and often moſt convenient method of applying heat is by the ſun's rays through the means of a powerful lens or mirror. It unites the great advantages of ſimplicity and extreme power, and has been employed moſt happily by Dr. Prieſtley and other philoſophers in ſeveral important experiments. Where the ſubſtance to be heated is to be at the ſame time debarred from the acceſs of the external air, the veſſel muſt be thin clear glaſs, that the cone of rays may be tranſmitted through with as little loſs as poſſible. The heat produced by the moſt powerful glaſſes (ſuch as that of Mr. Parker) appears fully to equal, in a ſmall ſpace, the effect of the blow-pipe fed with oxygen gas.

SPECIFIC GRAVITY, *Apparatus for.*

Though experiments on ſpecific gravity do not abſolutely belong to chemiſtry, it is neceſſary that the chemiſt be furniſhed with the means of aſcertaining the ſpecific gravity of both ſolids and fluids with tolerable accuracy, as it aſſiſts much in many chemical enquiries, and the effect of acids, alcohol, and ſome other reagents very materially depend on their degree of concentration which is known by their denſity or tenuity. Therefore the ſcales which the chemiſt employs ſhould allow to be uſed hydroſtatically, or elſe he ſhould be provided with an hydrometer, of which Mr. Nicholſon's (or that in which the point of immerſion is fixed) is by far the beſt. The ſpecific gravity of fluids may alſo be very conveniently taken in the following way: take a ſmall light bottle that ſtands firmly, and holds an ounce or two, or more, of water, the neck of which is ſtopped by a piece of barometer tube very accurately ground. Then counterpoiſe the empty bottle, and afterwards fill it entirely with diſtilled water at 60° recently boiled, till it riſes a little in the bore of the tube and find the weight. For greater eaſe in calculation it will be as well (if it can be done) to bring the water exactly to that height in the tube, at which its weight will be 500 grains, or 1000, or 1500, or 2000, &c. but this is not eſſential. Then mark the height moſt accurately with a fine file on two oppoſite ſides of the tube, and ſcratch on the bottle the weight both of the bottle and tube when empty, and of the quantity of water requiſite to fill it to the mark. This will then ſerve for the ſpecific gravity of all other fluids, as pure water is the ſtandard of compariſon for all bodies ſolid as well as fluid.

STILL. See DISTILLING *Apparatus*.

THERMOMETER. Several varieties of thermometer are made for philoſophical purpoſes, and in many experiments, particularly all thoſe connected with the ſubject of caloric, it is neceſſary to be well provided with them. To take in the entire range of thermometrical temperature from the moſt intenſe artificial cold to the boiling point of mercury requires a very long tube; but for moſt chemical purpoſes it is ſufficiently high if it is graduated to about 10 degrees above the boiling point, which will reach the temperature of moſt ſaline ſolutions when boiling.

For experiments on intenſe cold, it is neceſſary to have a ſpirit thermometer graduated about 100°. below 0. and the lower extremity of the ſcale ſhould be at ſome diſtance from the bulb, that the temperature may be obſerved without lifting the bulb out of any deep veſſel that may contain the freezing mixture. The moſt delicate and ſenſible thermometers are made with a very ſmall bulb, ſcarcely larger than the ſtem, and a tube of an extremely narrow bore, not larger than a horſe-hair. For chemical purpoſes alſo the ſcale ſhould either be ſcratched on the glaſs itſelf, or as this is difficult to be ſeen in a common light, an ivory ſcale ſhould be attached, without reaching ſo low as the bulb, that the latter may be ſafely immerſed in acid or corroſive liquors.

The thermometer ſcale has been differently divided by the original conſtructors, which often cauſes a good deal of trouble in comparing reſults of experiments made in different countries. Three ſcales are principally uſed: *Fahrenheit's*, which is employed in this country, in which the 0. is 32 degrees below the freezing point of water, and the interval between 0. and the boiling point of water is divided into 212 degrees, and conſequently the freezing point of water is 32°: *Reaumur's*, which has the 0. at the freezing point of water, and divides the interval between this point and the water-boiling heat into 80 degrees: and *Celſius's*, originally uſed in Sweden, and ſince adopted in France under the name of the *Centigrade*, which has, like Reaumur's, the 0. at the freezing point of water, but divides the interval between this and water-boiling heat into 100 degrees. The reaſon why Fahrenheit fixed his ſcale ſo far below the water-freezing point was founded on an erroneous hypotheſis relative to the real zero or point of abſolute privation of heat; but however it has this advantage over the two others, which is, that the diſtinction between the poſitive and negative terms (or which expreſs degrees above or below the zero) much leſs frequently occurs in any experiments, and ſcarcely ever in the regiſter of natural cold in temperate climates, by which many accidental errors are avoided.

In Appendix II. we have given the correſponding degrees of thoſe three thermometers, by which the reader may at once tranſlate the degrees of Reaumur's and Celſius's into the equivalent of Fahrenheit, or vice verſa.

* * * * *

A very ingenious thermometer has been invented by Mr. Leſlie, which he calls a DIFFERENTIAL THERMOMETER, as it expreſſes not the abſolute degree of heat, but the difference (when any exiſts) between the temperature of the two ſpots where its two bulbs are placed. Its uſe is explained under the article CALORIC.

The differential thermometer (Pl. IV. Fig. 54.) is made in the following way: ſelect two thermometer tubes with bores rather wider than uſual, and one a little wider than the other. Let the balls be blown as equal as the eye can judge and from .4 to .7 of an inch in diameter, and let the open end of the tube alſo be widened in a ſlight degree. The tubes muſt be of unequal length, the longeſt being nearly twice the length of the other. Then introduce into the longer tube a little ſulphuric acid tinged with carmine, ſufficient to fill about an inch of its cavity, join the two tubes together by the blow-pipe, and when joined, bend them in the form of the letter U. with the bulbs about 3 or 4 inches aſunder, making one flexure juſt below the juncture of the two tubes, where the ſmall cavity (which is repreſented in the plate) facilitates the adjuſtment of the inſtrument, which by a little dexterity is performed by forcing a few globules of air by the heat of the hand from one bulb to the other. Attach a graduated ſcale to the ſhorter tube, making the zero about the middle of it, and adjuſt to it the quantity of air in each bulb, ſo that when the bulbs are at the ſame temperature, the upper ſurface of the coloured liquor may juſt correſpond with the zero. Sulphuric acid is choſen as the liquor interpoſed between the bulb, on account of its bearing any heat or cold that would be uſed without being evaporated or congealed.

In this inſtrument the air incloſed in the bulbs is the ſubſtance which, by its expanſion or contraction, cauſes the motion of the coloured liquor up or down the ſcale, and as gaſſes are much more expanſible than liquids, the inſtrument is ſooner affected by minute changes of heat. But as the two bulbs are of equal ſize, and both filled with air, and ſeparated from each other by the intervening liquor, it is obvious that when the temperature is the ſame in each bulb, be it high or low, the preſſure on each ſide of the liquor is alſo equal, and it muſt remain ſtationary: ſo that it can only move when one bulb is warmer than the other. Hence the particular and ſole uſe of this inſtrument as a *Differential Thermometer.* The lower part of the inſtrument (or the ſpace included between the two bends) is cemented to an upright ſtem by which it is ſupported.

TROUGH. *Pneumatic.*

In all the common operations of receiving and transferring gaſſes they are held in jars, or other veſſels, previouſly filled with water, and inverted over this fluid. It is therefore neceſſary to have ſome kind of water-veſſel large and deep enough entirely to immerſe the air-jar, that every particle of common air may be diſplaced by the water before it receives the gas to be operated on. Dr. Prieſtley's firſt water trough for this purpoſe was a common oval or round tub, but as a jar full of air ſtanding inverted over water and immerſed in it for any depth, would readily be overſet by the preſſure of the water, this ingenious philoſopher adapted a ſmall hanging ſhelf ſuſpended from the ſides of the tub, and ſinking below the level of the water, only juſt ſufficient to confine the gas in any jar ſtanding upon it. This plan has been adopted with ſome little improvements in the pneumatic water troughs commonly uſed, of which Fig. 49. Pl. IV. is one of the moſt convenient kinds. *a* is a deep oblong trough made of thin tinned iron well japanned, generally 18 inches long, 9 broad, and 14 deep. About $3\frac{1}{2}$ inches from the top is a ſhelf of the ſame material, extending entirely acroſs the trough, and rather more than a third of its length, and fixed in its ſituation when required by two ſtrong wires. This ſhelf is given inverted in Fig. 50. to ſhew an oval rim projecting from it, in the center of which are two ſmall holes, the uſe of which is to ſecure and convey the gas into any veſſel ſet upon it (as the bottle in Fig. 49). This ſhelf has alſo two larger holes to receive two bottle ſupporters, Fig. 51. & *b.* Fig. 49. A trough of this ſize and conſtruction is very light when empty, and large enough for moſt operations.

Fig. 52. is a convenient trough for exhibiting experiments in the lecture room. It is ſimply a circular pan, 18 inches in diameter, with a looſe ſemicircular ſhelf ſupported to the requiſite height on three conical legs, on which a bell receiver is repreſented ſtanding. This pan is however too ſhallow to allow of any large veſſel to be immerſed, ſo that it muſt be previouſly immerſed in a deeper trough, and conveyed hither upon a plate or ſaucer.

Fig. 53. is a Mercurial Pneumatic Trough, which is indiſpenſible in moſt experiments on gaſſes abſorbable by water. It may be made either of a cloſe hard wood ſuch as mahogany, or cut out of a block of ordinary marble or freeſtone, or as is now more common, it is a thin iron caſe incloſed in wood. When made of wood it is often hollowed out of a ſingle piece, but if grooved and very neatly rabitted, it will anſwer nearly as well. In any caſe it ſhould alſo ſtand on a ſhallow wooden or iron diſh to catch the mercury, ſome of which is always ſpilling whatever care be uſed.

Theſe mercurial troughs muſt be made very ſolid to bear the great weight of metal that is required even for a very moderate ſized veſſel, and for the ſame reaſon and to ſave the great expence of the metal, they are always made much ſmaller than the water troughs. This will not appear an indifferent object when it is conſidered that half a hundred weight of this metal will not occupy a ſpace greater than about two quarts, which is but a very ſcanty allowance of room for a trough for chemical purpoſes.

In order ſtill more to economize room and conſequently mercury, only one ſide of the trough is ſunk deep (as ſhewn at *a* by the dotted line in the plate) being equally convenient for the immerſion of a jar. The ſhelf in a trough of this conſtruction is on each ſide of the well. It is uſeful alſo to have an iron ſtem ſupporting a ſemicircular clip, ſcrewed or otherwiſe faſtened into the ſubſtance of the trough a little beyond the deep circular part of the well, to ſupport a jar when inverted and heavy with mercury. A ſmall glaſs tube open at both ends and drawn out capillary at one extremity, is an uſeful addition to this apparatus, to enable the operator to ſuck up and collect the ſmall globules of mercury which will always be ſcattered about during theſe experiments.

TUBE OF SAFETY. (Fig. 60). See WOULFE's APPARATUS.

WATER BATH. See BATH and ALEMBIC.

WELTER's TUBE, or *Tube of Safety.*

WORM TUB. See DISTILLING APPARATUS.

WOULFE's APPARATUS. The invention of this apparatus forms almoſt an æra in chemical diſcovery, ſo great and various is its utility. Before it was known, the only veſſels that chemiſts employed for diſtillations were, either the alembic with its refrigeratory, or the retort with its receiver. The former was devoted almoſt excluſively to the diſtillation of thoſe fluids which are readily condenſed by cooling, and are not attended with the production of much permanently elaſtic or difficultly-condenſible vapour, ſuch as water impregnated with the aromatic parts of vegetables, alcohol, &c. whilſt the retort with its glaſs receiver, was reſerved for the diſtillation of the ſtronger acids, and other ſubſtances accompanied by much uncondenſible vapour. But here a great inconvenience ſubſiſted, for either enormouſly large receivers were required, or a conſiderable number of them with double openings like aludels, or elſe it was neceſſary to avoid the rupture of the veſſels by having a ſmall hole, which could be opened occaſionally, when the quantity of confined vapour was judged to be too great. But even this did not anſwer the purpoſe of the chemiſt compleatly, for much of the vapour given out during theſe diſtillations, is only uncondenſible for want of finding water or ſome other ſubſtance with which it may unite, ſo that a large proportion of the products of diſtillation were totally waſted. In experiments of reſearch too the old apparatus was peculiarly defective, as the gaſſeous products, which are often by far the moſt intereſting, were entirely loſt.

Glauber was aware of many of the defects of the old apparatus, and as early as about the year 1655, gave a very ingenious method of ſubſtituting to the ſeries of perpendicular aludel-ſhaped receivers, a lateral ſeries of plain ſtone or earthen jars, each connected with the other by earthen tubes bent at right angles, and the covers of each jar having two holes, one to receive the tube bringing the vapour from the adjoining jar or the retort, and the other for the paſſage of the tube which conveyed the exceſs of this vapour into the next in ſucceſſion. This arrangement is preciſely that of the bottles of the modern Woulfe's apparatus, but the jars which Glauber uſed were empty, and ſet in a larger veſſel full of cold water, ſo as to be kept always cool. (See *Glauberi Opera, Vol. 3. Furni Novi Philoſophici ſive Deſcriptio Artis Diſtillatoriæ Novæ. Pars. I.*)

The great improvement made to this apparatus by the late Mr. Woulfe,[a] was to fill theſe lateral veſſels with water, into which he dipped the extremity of each tube, bringing into it the uncondenſed part of the vapour, by which means a vaſt quantity of product is ſaved, which even in Glauber's method could not be ultimately detained; ſo that by having a ſufficient bulk of water in one or more of theſe lateral veſſels, no part of the product can eſcape detention except that which cannot condenſe, either alone or when paſſed through any liquid. Even this too may readily be ſaved, by adding to the laſt in the ſeries of bottles a curved tube, which conveys the gas to the pneumatic trough or gazometer, where its nature may be examined.

Inſtead of having the mouths of the lateral bottles wide enough to admit both tubes (that is, the one which brings the vapour into the bottle, and the other which conveys the uncondenſed part of it out of the bottle) it is a great improvement to have the bottles blown with two openings, as in *g* and *i* Fig. 59, and ſometimes a third is added as in *a* Fig. 58, for a particular purpoſe which will be preſently mentioned.

The eſſential parts of this apparatus therefore are, a Retort or any other veſſel in which the materials are heated; a Receiver to detain that part of the product which is condenſible by mere cooling; and a bent Tube proceeding from the receiver to the bottom of a bottle placed by its ſide, and full, or nearly ſo, of water, or any other liquid. If more than one bottle is employed, theſe are ranged ſide by ſide, and connected with each other by bent tubes, each of which proceeds from the top of the bottle immediately preceding, and plunges to the bottom of the liquid of the bottle next in order. Every part of the apparatus is air-tight except the end the furtheſt from the retort, ſo that every particle of vapour or gas has to traverſe the whole ſeries of veſſels, and to paſs through the liquid in every one of the bottles before it eſcapes into the air; and thus if at all condenſible by the liquid uſed, it can hardly eſcape condenſation.

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[a] Phil. Tranſ. for 1767.

Another part however is neceſſary to the perfection of this apparatus. When the diſtillation is nearly over, and the production of gas or vapour ſlackens, or ceaſes altogether, a degree of vacuum is always made in the retort, owing to the cooling of the elaſtic vapour which it contains. This circumſtance cauſes a ſimilar vacuum in the receiver, to fill which, a ſtrong abſorption or ſuction of the liquid takes place from the firſt bottle back into the receiver through the bent tube that dips into the bottle. This again cauſes an equal vacuum in the firſt bottle, which is filled by abſorption of fluid from the ſecond bottle through the communicating tube, and ſo on to the laſt; ſo that the moment that abſorption begins, a retrograde motion takes place through the whole apparatus. The inconvenience of this is the mixture of the products that takes place; for if, for example, the diſtillation of nitric acid is the proceſs, after the materials in the retort have given out every thing, the receiver, which was at firſt left empty, contains the concentrated acid, and the bottles contain water ſtrongly impregnated with nitrous vapour. But the moment that abſorption begins, the dilute liquor of the firſt bottle is poured into the receiver, which makes it impoſſible to collect any concentrated acid, unleſs the operator is on the watch to looſen the luting between the retort and receiver the moment he perceives the liquor to riſe in the bent tube between the receiver and the firſt bottle. To remedy this defect ſeveral contrivances have been adopted. The inventor, Mr. Woulfe, who was fully aware of it, employed an intermediate veſſel between the receiver and the firſt water-bottle which was left empty, and into which the bent tube from the receiver was immerſed only to a ſhort depth, in conſequence of which when the abſorption took place the liquor from the firſt bottle was poured into this intermediate bottle and went no further. This contrivance is very uſeful where only a ſingle water-bottle is employed, but where more than one is uſed, it is obvious that the liquors contained in them muſt mingle, though they all keep ſeparate from the contents of the receiver; for when any of the liquor of the firſt bottle paſſes into the intermediate bottle, an equivalent portion of the ſecond muſt pour into the firſt bottle, of the third, into the ſecond, and ſo on. Another contrivance (and which is now generally adopted) is to prevent the abſorption altogether by letting in the external air to fill the partial vacuum. This is done either by inſerting ſtraight capillary tubes into the different veſſels, or by a curved tube of particular conſtruction invented by Welter, and called *Welter's Tubes*, or *Tubes of Safety*. A ſingle example of the ſtraight tubes is ſhewn in Pl. IV. Fig. 58. *a* is a bottle with three openings, half filled with water, which receives the gas or vapour from the preceding bottle, or from the receiver; the exceſs of which after paſſing through the water of *a* paſſes by the tube *d* into the bottle *e*, and which is only looſely ſtopped; *c* is an upright glaſs tube with a very narrow bore which juſt dips into the water of *a*. Conſequently, when an abſorption takes place in the receiver and water is ſucked up by *b*, it immediately ſinks the level of fluid in *a* below the bottom of the tube *c*, which then gives the bottle *a* a free communication with the air, and prevents the liquor of *e* from paſſing into it. This plan of upright tubes may be adopted for every bottle of the apparatus, and it is convenient from its ſimplicity, and any perſon may fit this apparatus for himſelf ſimply by cutting a piece of glaſs tube of the proper length, running it through a perforated cork, and luting all the joinings. It has however the great inconvenience that it is inapplicable to the receiver itſelf (which is preciſely the place where it is moſt requiſite to prevent the abſorption) as this veſſel is quite empty at firſt, and the quantity of liquid is conſtantly increaſing; and indeed the increaſing bulk of the fluid in the bottles is an objection to this method, as the end of the tube becomes progreſſively lower beneath the level of the fluid, and may eaſily be too low to act properly.

The *Tube of Safety*, Fig. 60. is a ſingle glaſs tube bent as repreſented, and with a bulb blown in that part of the tube that lies between the upper and lower flexure. It has alſo a ſmall funnel at the top, which, however, is not very eſſential. This tube is ſometimes employed as a ſtopper to the tubulure of the retort, or to a ſeparate opening in the receiver, and ſometimes, as at *f* Fig. 59, it is cemented, by melting, into the tube paſſing from the receiver to the firſt bottle. Before uſing it, a little mercury is dropped down through the funnel, about ſufficient to occupy the ſpace of the tube that lies between the two lower flexures, which completely ſhuts up the acceſs of the external air whilſt the diſtillation is going on. But as ſoon as any vacuum is formed in the veſſel to which it is attached, the mercury is forced up by the preſſure of the atmoſphere into the bulb, and not being in ſufficient quantity to fill it, the external air paſſes by it in this place, and ruſhes into the apparatus. This very ingenious contrivance unites every convenience, for it ſupplies air to the vacuum preciſely in the place where abſorption begins, and in fact it renders uſeleſs all other contrivance to prevent abſorption in any diſtant part of the apparatus. The only objection to the Welter's tube is its great fragility, more eſpecially when connected with a conducting tube as in Fig. 59, which when firmly ſtoppered or luted in its place is liable to ſnap with the leaſt ſhake, and beſides a great many are broken in the making and grinding even by ſkilful artiſts. The other parts of Fig. 59 are obvious by mere inſpection. *a* is an iron ſtand generally furniſhed with three ſliding rings of different diameter, one of which is here repreſented; *b* is a ſmall Argand lamp, very convenient for chemical purpoſes, being flat and low; *c* is a tubulated retort; *d*, a tubulated receiver, ſtanding on a convenient wooden tripod *e*; *f* is the conducting tube with the Welter's tube affixed to it. The receiver *d* is left empty in the beginning of the diſtillation, and the vapour which does not condenſe there paſſes through *f* into the bottle *g*, and through *h* into the bottle *i*. To make the apparatus complete for experiments of reſearch, a bent tube may be faſtened in the lateral opening of *i*, conducting to a pneumatic trough.

Fig. 57 is a ſmall apparatus nearly ſimilar to one that has been lately ſuggeſted, of a ſeries of Woulfe bottles without luting, in which the ſeveral parts have conſiderable play, ſo as to avoid any ſtreſs on the thin brittle tubes of which it is compoſed. Only a ſingle ſpecimen of the principle acted on is here introduced, which is in the veſſel *d*. *a* is a matraſs ſtanding on one of the rings of an iron ſtand; *b* is a bent tube, one leg of which is cemented into the cork of *a*, the other paſſes down into the ſhort jar *d*, through a much wider glaſs tube *c*. The lower end of *b* ſhould be a little curved, ſo that any bubble of gas paſſing out of it may clear the edge of the tube *c* and paſs up into the jar *d*, and both *b* and *c* dip a little way below the level of the liquor in *d*. The gas then paſſes out through *e* into the bottle *f* and ſo on, which may alſo be furniſhed with a wide tube ſimilar to *c*, through which the lower part of *e* may paſs. In all the common Woulfe's apparatus there is a perpetual riſk of breaking the thin conducting tubes from the circumſtance of having both of their lower extremities tightly faſtened down either by lutes or by grinding, which gives a great ſtreſs to the middle of the tube unleſs the bottles remain perfectly upright, and exactly at the proper diſtance from each other. Whereas in this apparatus only one end of the conducting tube is fixed, and the other moves at eaſe within the larger tube that ſerves as its caſe, and any part of it may be inſtantly withdrawn and put on again without deranging the reſt. The larger tube in this caſe alſo ſerves to prevent abſorption as the tube *e* in Fig. 58.

Thus, for example, if it is wiſhed to make liquid oxymuriatic acid by this apparatus, put the mangane ſe and other materials in the matraſs *a*, and a ſmall quantity of water in *d* and fill *f* two-thirds full. The oxymuriatic gas paſſes along *b* into the ſmall jar *d* where the common muriatic acid which it contains is detained by the ſmall quantity of water in *d*, and the reſt of the gas iſſues out through *e*, and goes to impregnate the water in *f*. If the materials in the matraſs *a* are not ſufficient, it may be drawn away by lifting out the tube *b*, and the veſſel returned to its place without moving any other part of the apparatus. It ſhould be obſerved, that wherever there is an open tube communicating with the bottles as at *c*, the greater preſſure produced in the veſſel by the influx of gas, and the reſiſtance of the water into which the conducting tube *e* immerges, will cauſe the liquor in *d* to riſe in the open tube *c*, and it will overflow, unleſs care is taken to proportion the height of the open tube to the preſſure which it is to counteract.

Another variety of Woulfe's apparatus is given in Pl. III. Fig. 42. in which the abſorption is prevented by a glaſs valve inſtead of a tube of ſafety. The conſtruction of this valve is the ſame as that of Nooth's apparatus, which has been already explained, and is given ſeparately in Fig. 45. *a* (Fig. 42.) is the retort; *b* the receiver; *c* the glaſs valve; *d* an upper veſſel into which is put the liquor to be ſaturated by the paſſage of the gas, and the reſidue paſſes on to *e*, *f*, *g*, *h*, *i*, as repreſented. The ſame apparatus may be uſed with equal convenience by removing the tube *e* and further part of the apparatus, and ſubſtituting the bottles *a* and *b*, Fig. 44, for which purpoſe the lower part of *a* is ground to fit the veſſel *d*, Fig. 42. The mode of bending the tube *g* is ſhewn in Fig. 43. It is firſt ground to fit each bottle, then held over a large lamp, and bent above each ground part, after which another flexure is made in the middle; and the exact curve of the laſt is fitted by fixing the tube in the bottles, and ſoftening it by a lamp, by which it preciſely accommodates itſelf to its ſituation.

APPENDIX TO VOL. II.

L.

LACTIC ACID. See Blood.

LATIALITE. Haüyne.

The colour of this mineral in those specimens that are opake is indigo blue, and in those which are translucent is bluish green. It occurs massive, in grains, and in a single instance in extremely minute brilliant crystals. Its hardness is a little superior to that of quartz; it is very brittle; its fracture is vitreous, uneven; sp. gr. about 3.2.

Before the blowpipe it is infusible *per se*, but with borax affords a yellow glass. When finely pulverized it gelatinizes with the mineral acids. Its constituent parts, according to Vauquelin, are,

30.	Silex
15.	Alumine
20.5	Sulphat of lime
11.	Potash
1.	Oxide of iron
5.	Lime
	an atom of sulphuretted hydrogen
82 5	
17.5	loss, probably for the most part water.
100 0	

It occurs at the lake Nemi, and near Albano and Frascati, accompanied by mica and green hornblende; and at Monte Somma among the ejections of Vesuvius, accompanied by idocrase, augite, mica, and meionite.

In many of its external characters and in its chemical composition, this mineral bears a striking analogy with lapis lazuli.

LAUMONITE.[a] Efflorescent Zeolite. This mineral occurs in aggregate crystalline masses, deeply striated externally, or in separate crystals. Its primitive form is a rhomboidal prism, the angles of which approach to right angles: this figure is further divisible by joints parallel to its axis and to the greater diagonal of the terminal planes. Its fracture is lamellar; it is colourless and transparent. Sp. gr. 2.23.

When exposed to the air it undergoes with more or less rapidity a spontaneous change, in consequence of which it first loses its transparency, and presents a shining white appearance, then the natural joints, especially those parallel to the axis of the prism, become very apparent, and lastly the whole separates into a white powder similar to that resulting from the decomposition of Glauber's salt. This change can only be prevented by immersion in water or by a varnish.

The laumonite was at first supposed to be peculiar to the lead mine of Huelgoet in Britanny, but M. de Bournon has since discovered it among specimens from Ferroe, from near Paisley, and from Portrush in Ireland; none of these however are so strikingly efflorescent as the specimens from Brittany.

LEAD.

§ I. *Ores of.*

Native Minium.[b] — Plomb oxydé rouge *Haüy*.

The colour of this substance, like that of factitious minium, is a vivid scarlet: it is amorphous and pulverulent, but when examined with a lens exhibits a flaky and crystalline texture. When gently heated before the blowpipe it acquires a darker colour, but recovers its original tint by cooling; by a stronger heat it melts to litharge, and on charcoal is reduced to metallic lead. It occurs in the lead mines of Breylau in Westphalia, sparingly disseminated through compact calamine, and mixed with galena and carbonate of lead.

Arseniate of Lead.[c]

The following particulars concerning this ore (recently discovered in Cornwall by Mr. Gregor) may serve to correct the account given in the Dictionary.

Its colour is wine yellow passing into brownish yellow; it occurs in small slender hexahedral crystals and capillary fibres: it varies from translucent to transparent with a vitreous resinous or silky lustre: when transparent it scratches glass; it is easily frangible, sp. gr. 6.4.

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[a] Geol. Trans. i. p. 77. [b] Phil. Trans. for 1806. p. 267. [c] Ibid. 1809. p. 195.

Before the blowpipe it melts into a brownish yellow mass; when ignited on charcoal it exhales arsenical vapours, and is reduced to metallic lead. It appears to be composed of

69.76	Oxide of lead
26.4	Arsenic acid
1.58	Muriatic acid
97.74	
2.26	silex, alumine, oxide of iron and loss
100.00	

It occurs in Huel Unity, in the parish of Gwennap, Cornwall, mixed with native copper, grey and black copper, and octohedral red copper.

§. 2. *Chemical Properties.*

It is generally admitted that there are three oxyds of lead, the *yellow*, the *red*, and the *brown*, or puce-coloured. Of these, the yellow is the lowest in oxydation, but its elements have been very differently stated by chemists. It is the most important of all in a chemical view, as it appears to be the basis of most of the salts of this metal.

The oxydation of lead was thus examined by professor Berzelius.[d]

Yellow Oxyd and Litharge. 10 parts of pure lead (reduced from the crystallized nitrat) were dissolved in nitric acid in a glass vessel, the solution evaporated to dryness in a platina vessel, and made red-hot. It left 10.77 parts of yellow oxyd. A second experiment gave 10.775 parts. A third experiment made entirely in a glass vessel, gave 10.78. It was found that a minute quantity of the nitrat of lead had sublimed in the experiment, which of course made this result of yellow oxyd rather too little. 10 parts of lead dissolved in nitric acid were precipitated by carbonat of ammonia, giving 12.9025 parts of carbonat of lead, which left 10.75 of yellow oxyd when ignited. Another similar experiment gave 10.95. Therefore, making a little allowance for loss, the yellow oxyd is thus composed.

Lead . .	92.765	100.0
Oxygen .	7.235	7.8
	100.000	107.8

Red Oxyd or Minium. Common red lead contains besides the proper red oxyd, some yellow oxyd, sulphat and muriat of lead, oxyd of copper, and silver. The yellow oxyd was dissolved out by weak distilled vinegar which hardly acts upon minium. The minium thus purified was strongly heated, by which it was changed to yellow oxyd by losing oxygen, and the other impurities being allowed for, it appeared that purified minium consisted of

Lead . . .	90	— 100.
Oxygen . .	10	— 11.07
	100	— 111.07

Brown Oxyd. This oxyd is produced as mentioned in our original article, by digesting nitric acid on minium, which deoxygenates a part and superoxygenates the remainder, the former being reduced to yellow oxyd and dissolved in the acid, and the latter being the brown oxyd. This is composed, according to Berzelius, of

Lead . . .	86.51	— 100.0
Oxygen . .	13.49	— 15.6
	100.00	— 115.6

Hence it appears probable, that in these three states of oxydation, 100 parts of lead take up oxygen in the proportion of 1, 1½ and 2, the numbers 7.8, 11.07 and 15.6 being nearly in this ratio.

Sulphuret of Lead. Equal parts of lead and pure sulphur were melted together in a retort, and kept at a red heat till nothing further was expelled. The composition of the sulphuret thus found, gave

Lead . .	86.51	— 100
Sulphur . .	13.49.	— 15.6
	100.00	— 115.6

Lead and sulphur appear to unite in no other proportions. When this sulphuret of lead is fully oxygenated by boiling with nitro-muriatic acid, the whole is exactly changed to neutral sulphat of lead, the sulphur when converted into sulphuric acid being just sufficient to saturate the lead when changed to yellow oxyd, (this oxyd being the base of all the salts of lead.) See the article *Affinity*.

Muriat of Lead. 5 parts of yellow oxyd of lead dissolved in muriatic acid, and the solution evaporated to dryness in the same vessel, gave 6.187 parts of fused muriat of lead. A small portion of the salt however was volatilized during the process. Muriat of lead therefore consists of from 80.8 to 81. per cent. of oxyd of lead, and 19. to 19.2 of acid.

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[d] An. Chim. tom. 78.

10. parts of fused muriat of lead were dissolved in nitric acid, and the solution decomposed by nitrat of silver. The supernatant liquor was separately evaporated to dryness, and the soluble salt then dissolved out by water, by which a little muriat of silver that had been dissolved in the excess of nitric acid was recovered and added to the other portion. The whole of the muriat of silver when fused weighed 10.32 parts, which contain according to Berzelius 1.9644 of muriatic acid.

Another 10 parts of fused muriat of lead were dissolved in nitric acid, an excess of sulphuric acid added, the whole evaporated till all was driven off except sulphat of lead with a little sulphuric acid in excess; which last was separated by hot water. The neutral sulphat of lead well dried weighed 10.92, containing by estimation 8.03876 of suboxyd of lead. These two experiments very closely agree, so that fused muriat of lead may be taken as containing

Muriatic acid .	19.644	—	100.00
Yellow oxyd of lead	80.356	—	409.06
	100.000	—	509.06

by one estimation, and by the other 19.61 per cent. of muriatic acid.

Carbonat of Lead. 10. parts of carbonat of lead dried at a high temperature were kept red-hot in a platina crucible, and left 8.35 of suboxyd of lead. The carbonat of lead therefore contains

Carbonic acid . .	16.5
Yellow oxyd of lead	83.5
	100.0

Sulphat of Lead. From a great variety of experiments, which agree pretty closely, professor Berzelius fixes the composition of this salt at

Sulphuric acid .	26.346	100	35.9
Yellow oxyd of lead	73.654	279	100.0
	100.000	379	135.9

Nitrat and Nitrite of Lead. The salts produced by the combination of oxyd of lead and nitrous or nitric acid, are numerous and difficult to be made out with accuracy. Besides the common crystallized nitrat of lead formed by the solution of lead in nitric acid, there are other compounds formed either by digesting nitrat of lead with an additional quantity of metallic lead (as mentioned by Proust) or with more oxyd of lead; or else by the partial decomposition of these salts, by which salts with excess of base are obtained.

In addition to what has been mentioned on this subject in our original article, we shall merely state the results of the experiments of Berzelius and of Chevreul.[d]

Nitrat of Lead. This well known salt which forms large white opake octohedral crystals appears to contain no water of crystallization. It contains according to Berzelius

Nitric acid . . .	32.7	—	100.
Yellow oxyd of lead	67.3	—	205.09
	100.		305.09

Chevreul agrees almost exactly with this calculation.

Subnitrat of Lead. This salt may be made in two ways, either by digesting the nitrat with oxyd of lead; or by adding ammonia to the nitrat, less than will decompose the whole salt, whereby a nitrat of ammonia and a subnitrat of lead are produced. Berzelius adopts the latter method. A precipitate took place on adding a little ammonia to nitrat of lead, which was well edulcorated and dried to separate all the ammoniacal salt. A portion of this gradually heated to redness in a retort gave out much uncondensible nitrous vapour and left 80.5 per cent. of bright lemon-yellow oxyd. It therefore contained no water but consisted merely of

Nitric acid . . .	19.5	—	100.
Yellow oxyd of lead	80.5	—	412.9
	100.0		512.9

Double Sub-nitrat of Lead. The last experiment was repeated with the variation of digesting the mixed nitrat of lead and ammonia for some time and then washing the precipitate with boiling water. This precipitate dried and decomposed as before lost 9.7 per cent. of acid, and therefore consisted of

Nitric acid . . .	9.7	—	100.00
Yellow oxyd of lead	90.3	—	930.92
	100.0		1030.92

M. Chevreul obtained the first subnitrat by boiling the nitrat of lead with yellow oxyd and allowing the clear liquor to cool in a well corked phial (to keep out the carbonic acid of the atmosphere) by which a number of pearly crystalline scales separated, which form the subnitrat in question. This salt is sweet and astringent, and when a current of carbonic acid is passed through, much carbonat of lead separates, and the nitrat returns to the state of common nitrat. The elements of this subnitrat are stated at 19.86 per cent. of acid and 80.14 of yellow oxyd, which very closely agrees with Berzelius.

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[d] An. Chim. tom. 83.

In the three nitrats of lead just described, 100 parts of nitric acid saturate 205.09, 412.9 and 930.92 parts of oxyd respectively. The two first are as nearly as can be expected in the simple ratio of 1 : 2, but the third does not coincide with any simple ratio. In all these the acid is the *nitric* and the oxyd is to all appearance the *yellow oxyd*.

Nitrite of Lead. This salt was first observed by Proust, and is obtained by boiling the common nitrat of lead with *Metallic Lead*, as described in our original article, and is considered by Proust as a nitrat of lead the base of which is at a lower state of oxygenation than the yellow oxyd, and by Dr. Thomson as a compound of the yellow oxyd with an *acid* at a lower state of oxygenation, and is therefore a *nitrite* of lead. It is obvious that either the acid or the oxyd must be in this state of diminished oxygenation, since in its preparation the metallic lead must absorb that portion of oxygen necessary for its solution from one or other or both of the constituents of the common nitrat of lead with which it is digested.

This subject has been examined with great care by Berzelius and Chevreul, with a remarkable agreement in their results.

When 20 parts of nitrat of lead are boiled in water with 12.4 parts of metallic lead (which is equal to the lead contained in the salt) the whole dissolves in some hours into a deep yellow liquid, which on cooling becomes the yellow crystallized mass described by Proust. This is the *Nitrite of Lead.* It has indeed a slight excess of base, so as to act like an alkali on vegetable colours, and therefore might with more strictness be called a *subnitrite*, but we shall retain the term of simple *nitrite of lead* to distinguish it from a subnitrite with a double proportion of base, to be presently described.

This nitrite of lead is also formed whatever be the proportion of lead employed with the nitrat of lead; but when the lead is in excess and the boiling too long continued, a brick-red salt gradually appears, which is the proper *subnitrite of lead.*

The nitrite of lead forms yellow foliated crystals. Its taste is slightly astringent and sugary; 100 parts of boiling water dissolve about 9½ of the salt, but the same portion of cold water takes up scarcely more than 1¼. Sulphuric, nitrous and acetic acids decompose this salt and expel from it nitrous vapour, particularly when heated. Carbonic acid passed through a solution of this nitrite, partially decomposes it and separates a carbonated oxyd. Carbonated potash entirely decomposes it into carbonat of lead and nitrite of potash. When the nitrite is gradually heated it loses its acid and passes to the state of yellow oxyd.

The subnitrite of lead is produced, as above described, by boiling nitrat of lead for many hours with more metallic lead than it can take up: 10 parts of the nitrat by long boiling will thus dissolve about 12 parts of metallic lead, and the solution on cooling lets fall small brick-red crystalline plates, whilst the supernatant liquor contains a mixture of both these nitrites. These brick-red crystals are the *subnitrite of lead*, and consist of nitrous acid and a double portion of yellow oxyd of lead to that of the nitrite. This subnitrite is very little soluble in water, 3 parts requiring 100 of boiling water for solution. It is copiously precipitated by carbonic acid gas, or even by exposure to air. M. Chevreul gives the elements of the *Nitrite of Lead* to be

Nitrous acid	18.15	—	100.
Yellow oxyd	81.85	—	450.
	100.00		550.

and of the *Subnitrite of Lead*

Nitrous acid	9.9	—	100.
Yellow oxyd	90.1	—	910.
	100.0		1010.

Berzelius agrees pretty nearly with this estimation, so that the base of this subnitrite is a double proportion of that of the nitrite.

We shall conclude this article by noticing a singular production of the *Peroxyd* or *Brown oxyd* of lead observed by M. Chevreul. This oxyd is generally produced, as before mentioned, by digesting minium in nitric acid, by which a portion of it *loses* oxygen to pass to the state of yellow oxyd and dissolves in the acid, and the other part *gains* oxygen and becomes the insoluble brown oxyd. M. Chevreul has observed this unequal partition of oxygen in a different way: some flint glass (containing much minium) was heated in a platina crucible with thrice its weight of caustic potash, and the fused mass was digested with water. An alkaline solution of silex and yellow oxyd of lead was produced, and on remaining at rest it deposited a brown crystallized powder, which was the brown oxyd, whilst the crucible itself and the platina spoon used to stir the materials were lined with a metallic coating consisting of an *alloy of lead and platina.* This singular fact can be explained by supposing that the alkaline solution at first contained the whole of the lead of the glass in the state of yellow oxyd, but that the affinity of lead for platina then determined the precipitation of a small part of the lead in the metallic state on the platina of the vessel, whilst another portion of oxyd of lead taking up the oxygen of this reduced lead, passed into the state of brown oxyd, in which the metal is in the highest state of oxydation. That the brown oxyd was formed in consequence of the reduction of part of the oxyd of lead, and was not contained as such in the glass, is obvious from the intense heat employed in glass-making, which indeed is at all times sufficient to expell much oxygen, even from the minium used as a flux, and to reduce it to yellow oxyd.

LIME *(Basis of.)* See CALCIUM.

M

MADREPORITE.

A new analysis of this mineral has been published by Klaproth,[a] from which it appears to be composed of

93.	Carbonate of lime
0.5	Carbonate of magnesia
1.25	Carbonate of iron
0.5	Carbon
4.5	Siliceous sand
99.75	

MANGANESE.

An elaborate series of experiments on the salts and oxyds of this metal has been given by Dr. John of Berlin,[b] which appear to have been conducted with much attention. A few particulars may be mentioned.

Regulus of Manganese. This was prepared in the usual way, by reduction of the purified oxyd in a crucible lined with charcoal. The oxyd was prepared in the following manner. Some of the purest native black oxyd of manganese was dissolved to saturation in muriatic acid, a little nitric acid was added, the liquor was reduced by evaporation, then diluted with water, saturated with alkali and digested with pieces of iron to separate most of the copper contained in the solution. A little potash was then added, followed by oxalat of potash, which separated the iron in form of oxalat in twenty-four hours. The lead, if any, was then separated by sulphat of soda, and the manganese by carbonat of ammonia. But the carbonat of manganese is not yet quite free from copper, as prussiat of potash gives a peach-flower coloured precipitate, instead of one perfectly white, which occurs when the manganese is quite pure. The carbonat of manganese must therefore be digested with water and pure ammonia, redissolved in sulphuric acid, and then just supersaturated with ammonia and digested for a time, by which the remaining oxyd of copper falls down mixed with a little oxyd of manganese, after which the supernatant liquor will yield with carbonat of ammonia a perfectly pure oxyd of manganese.

This purified oxyd was reduced in a Hessian crucible lined first with a paste of silex, alumine and charcoal, over which charcoal powder alone was pressed down and a conical cavity was cut out to receive the oxyd of manganese previously mixed with a little oil and repeatedly calcined, to produce an intimate union of the oxyd with the charcoal of the oil. The reduction was effected in a very intense heat of a forge-furnace, kept up for an hour and a half, after the crucible had been gradually heated for an hour. From 830 grains of the pure carbonat the author obtained repeatedly about 250 grains of the regulus of manganese.

This regulus when made from pure oxyd leaves about one per cent. of its weight of charcoal when digested with acids, but if it contains any iron, the charcoal is greater. This charcoal may be extracted by melting the metal again under borax, which requires less heat than that employed for the first reduction.

Carbonat of Manganese. All the solutions of manganese when decomposed by an alkaline carbonat give a white carbonat of manganese, which appears to be the only salt of this species. The metal is in the state of suboxyd. When the carbonat is yellowish or brown it is probably (if no other metal is present) a mixture of carbonat and brown oxyd of manganese.

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[a] Analyt. Ess. ii. p. 218.

[b] Journ des Mines, tom. xxii. and xxiii.

The white carbonat is tasteless, unchangeable by exposure to air in a low temperature, and may be dried in a gentle heat. When decomposed by ignition in close vessels it gives

Suboxyd of manganese	55.84
Water	10.00
Carbonic acid . .	34.16
	100.0

The suboxyd left after ignition is greenish-grey, and this suboxyd may be considered as the basis of all the salts of manganese.

Sulphat of Manganese. Sulphuric acid when diluted dissolves metallic manganese with copious disengagement of hydrogen of a peculiar smell. 100 grains of metal are exactly saturated with 190 grains of sulphuric acid of 1.86 sp. gr. and this solution decomposed by carbonated ammonia gives 205 grains of carbonat of manganese dried at 77° Fahr. This will give 48.6 per cent. of metal in this carbonat.

Sulphuric acid dissolves the suboxyd of manganese with equal ease, and forms a solution exactly similar to the former, which crystallizes easily. This salt was analyzed by muriat of barytes to separate the sulphuric acid, and by carbonat of ammonia for the metallic oxyd. Estimating the acid of sulphat of barytes at 34 per cent. and the suboxyd of manganese at 55.84 per cent. of the dry carbonat, the crystallized sulphat of manganese contains

Sulphuric acid . .	33.66
Suboxyd	31.00
Remains for water .	35.34
	100.00

Muriat of Manganese. The author has succeeded in obtaining large tabular crystals of this salt, quite transparent and rose-coloured. These crystals deliquesce rapidly in the air. They were analyzed by nitrat of silver to ascertain the muriatic acid, and by carbonat of ammonia for the manganese. Reckoning (after Klaproth) 20.5 of acid in 133 of luna cornea, the crystallized muriat of manganese will contain

Suboxyd	38.50
Muriatic acid . .	20.04
Remain for water .	41.46
	100.00

When a current of oxymuriatic acid gas is passed through a solution of this salt, it presently stiffens very considerably and nearly the whole becomes a crystalline mass, which again becomes fluid in the air. If this liquid is evaporated, the pungent smell of oxymuriatic acid goes off, black oxyd of manganese falls down, and the remaining solution returns to the state of common muriat of manganese.

On the Oxydation of Manganese. The very great disagreement on this subject between the experiments of the most accurate chemists shews the extreme difficulty of determining with any certainty the numbers and proportions of the oxyds of manganese. On the one hand the metal itself and its lowest oxyd have a constant tendency to absorb oxygen from the atmosphere: and on the other hand the highest oxyd will readily give out oxygen at a very moderate encrease of temperature; so that it is very difficult to obtain any quantity of oxyd of this metal of a perfectly uniform state of oxydation throughout.

Dr. John, who is fully aware of these difficulties is inclined to fix the number of definite oxyds of manganese at three, namely, the Green, the Brown, and the Black, of which the green is the lowest oxyd. He thus endeavours to analyze them.

The Green Oxyd. Eighty grains of metallic manganese were put in a vessel containing water. The gas obtained was 24 ounce measures and was hydrogen, containing probably some atoms of the metal in solution, as it had a peculiar smell and burnt with a green flame. The gas was given out for a whole day, after which it ceased and was not renewed by heating the contents. The greenish oxyd remaining at the bottom of the water was quickly dried and weighed 92 grains.

This experiment did not much differ from the composition of the green oxyd as the base of the carbonat, and hence the author considers the oxygen as 13 per cent. on the average, and therefore the green oxyd will consist of

Manganese	87.	—	100.
Oxygen	13.	—	14.942
	100.		114.942

Brown Oxyd. This was formed simply by exposing the last mentioned green oxyd to the air till it gained no more weight, and drying it hastily. It was a pure deep brown colour, and consisted of

Manganese	80.	—	100.
Oxygen	20.	—	25.
	100.		125.

Black Oxyd. This oxyd which is considered as the highest possible in oxygenation, was prepared by dissolving a given weight of metallic manganese in nitric acid, and evaporating the entire solution to dryness in a heat barely sufficient to expell and decompose all the adhering nitric acid, without separating oxygen from the newly formed oxyd. In this manner the black oxyd will contain

Manganese	71.33	—	100.00
Oxygen	28.67	—	40.19
	100.00		140.19

This oxyd gives an abundance of oxygen gas at a red heat, and hence the extreme difficulty of driving off all the last portions of nitric acid, and at the same time just avoiding the heat which will change any portion of this oxyd to a lower term of oxygenation.

The following statement of the number and composition of the oxyds of manganese is given as the result of Pr. Berzelius's experiments,[c] but the particulars are not mentioned.

1. The lowest oxyd or suboxyd is the grey powder which forms on the surface of metallic manganese when kept in phials closed only by a cork.
2. The green suboxyd of Dr. John described above.
3. The oxyd which is the base of the sulphat of manganese.
4. An oxyd of higher degree.
5. The superoxyd or native peroxyd of manganese.

With regard to these five oxyds, the second, third and fourth are stated to have been analyzed by the author, and to contain on 100 of metal, 14, 28, and 42.16 parts of oxygen respectively, whence, adapting these to the doctrine of definite proportions, the composition of the two extreme oxyds is assumed to be 7.026 on 100 in the lowest and 56.215 in the highest oxyd. The five oxyds therefore will be as follows.

	Oxygen		*Metal*
1st contains	7.026	to	100
2d ———	14.052		——
3d ———	28.104		——
4th ———	42.156		——
5th ———	56.208		——

MEIONITE.

This mineral has hitherto been found only in minute aggregated crystals. Its primitive form is a strait prism with square bases; it also presents six and eight-sided prisms, terminated by low tetrahedral pyramids. Its colour is a translucent greyish-white, its lustre is vitreous; its longitudinal fracture is foliated in two directions, its cross fracture is conchoidal. It scratches glass.

Before the blowpipe it melts easily into a spungy white glass. It occurs among the substances ejected by Vesuvius, generally lining cavities in white granular limestone.

MELILITE.

It occurs in the form of small rectangular parallelipipeds and octohedrons of a pale yellow and orange colour, which are often covered with a brownish red crust. It gives fire with steel. When pulverized and put into nitric acid, it becomes perfectly gelatinous. In small fragments it melts before the blowpipe into a transparent glass.

It has been found only near Rome, at Capo di Bove.

MENILITE.

It occurs in tubercular masses of a moderate size, striped externally bluish grey and redish brown. Internally it exhibits a hair brown colour, and a glistening somewhat resinous lustre. It is strongly translucent on the edges, and presents a flat conchoidal or splintery fracture. It is hard, brittle and easily frangible.

Its constituent parts, according to Klaproth, are

85.5	Silex
1.	Alumine
0.5	Oxyd of Iron
0.5	Lime
11.	Water and inflammable matter
98.5	

It is found at Menil Montant near Paris, imbedded in a white slaty rock, and appears to have a considerable analogy with the flints, semi opals and hornstones that are found in the chalk, and in the strata above it.

MORDANT. See Dyeing.

MURIATIC ACID. OXYMURIATIC ACID. CHLORINE. EUCHLORINE.

An immense mass of interesting matter has been bestowed within these last few years on muriatic acid, since the laborious but fruitless attempts of Dr. Henry to discover its base, with which we concluded our former account of this singular substance.

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[c] An. Chim. tom. 83.

The facts which have been discovered have led to two totally distinct theories on the constitution of this acid, which we shall mention to assist the reader in following the experiments to be related.

1. The opinion of the *acid* nature of this substance, modified by the results of the experiments of Messrs. Gay Lussac and Thenard is the following. Muriatic acid is, like the other acids, a compound of some base (hitherto unknown) and oxygen; it has never been obtained in a separate state, as it is only known to chemists as *Muriatic Acid Gas*, or as forming a part of the alkaline, earthy, or metallic *Muriats.* In the former case, the muriatic acid is intimately combined with about a fourth of its weight of *water* (or of the oxygen and hydrogen which are the elements of this quantity of water), and this is absolutely essential to the existence of muriatic acid *in the gasseous state*, so that under no circumstances can this acid be expelled from its solid combinations, unless such a quantity of water is present as will unite with the gas at the moment of its formation, and will then amount to about a fourth of the weight of the gas. This water exists in muriatic gas in a different mode of combination from that which constitutes the common hygrometrical moisture of gasses, and therefore cannot be separated by solid potash, lime, dry muriat of lime, or intense cold, which are the means successfully used to render the other gasses dry. But when muriatic acid gas is united with any of the alkaline, earthy, or metallic bases, that portion of water which was essential to the acid in an insulated state is no longer retained, and may be expelled from most of them (though often with considerable difficulty) by mere heat.

Oxymuriatic acid on this theory is a compound of muriatic acid and oxygen; and oxymuriatic gas contains oxygen equal to half its volume; but the muriatic acid gas with which it is united is not combined with water, as it is in the insulated state of muriatic acid gas, but if it contains any water, it is only as common hygrometric moisture, which may readily be abstracted by any of the means above mentioned. Hence, in order to convert dried oxymuriatic acid gas to muriatic gas, it is necessary either to abstract oxygen, and to add water in substance; or else to add hydrogen, which by uniting with the excess of oxygen may produce water, this, as before mentioned, being essential to the constitution of muriatic acid gas.

2. The theory adopted by Sir H. Davy, is the following.

Oxymuriatic acid is a substance hitherto undecompounded, and therefore must at present be considered as an element; it contains no oxygen, at least none has ever been extracted from it; it unites with most metals and salifiables bases, forming the *muriats*, which therefore are not (like the sulphats, nitrats, &c.) compounds of an *oxydated* base and an acid, but are composed merely of the base and of oxymuriatic acid. Thus for example, common salt, or muriat of soda, when perfectly dry, is according to this hypothesis composed, not of soda and muriatic acid, but of sodium and oxymuriatic acid, and so of the rest. Oxymuriatic acid will however unite with oxygen, forming a very singular compound, whose properties have been discovered by Sir H. Davy. This eminent chemist gives the name of *Chlorine* to oxymuriatic acid, and of *Euchlorine* to the compound of oxymuriatic acid and oxygen, which will be presently described.

Muriatic acid according to this theory, is a compound of oxymuriatic acid and hydrogen in equal volumes; it contains no water of composition, for none can be procured from it, unless by substances that contain oxygen, and the quantity of water produced is exactly equal to the oxygen contained in the substance employed, added to the hydrogen supposed to exist in the muriatic acid gas. The salts called *muriats* are, when perfectly dry, composed of oxymuriatic acid and the respective bases, but not in the state of oxyds; but as soon as water is added to a dry muriat, a double decomposition takes place, the oxygen of the water goes to the base of the muriat converting it to an oxyd, the hydrogen of the water unites with the oxymuriatic acid, converting it to muriatic acid, and the compound now becomes really a muriated oxyd. On the other hand if this muriated oxyd is again dried in the heat of ignition, the salt is again decomposed, the hydrogen of the muriatic acid escapes with the oxygen of the oxyd in the form of water; and the salt returns to the state of a simple binary compound of oxymuriatic acid and the base.

We shall now give a short abstract of several of the most important series of experiments on these compounds, beginning with those of Messrs. Gay Lussac and Thenard.[a]

The first object of enquiry is the existence of water in gasses. When common air is enclosed over mercury in contact with dry potash, or muriat of lime, it is universally known that these substances absorb the moisture that the air held in solution, and leave it perfectly dry. If instead of potash or muriat of lime, a little *fluoboracic acid gas (which article see)* be added, an immense cloud of dense vapour is produced owing to the combination of this acid gas with the moisture of the air. But if fluoboracic gas be added to another portion of air that has previously been in contact with potash, or with muriat of lime, no cloud whatever takes place. Hence it is inferred, that the air naturally contains a quantity of moisture dissolved in it, (termed by these chemists *hygrometric water*) which is simply absorbed by the potash, fluoboracic gas, or any other substance that has a strong affinity with water. If the air is exposed to an intense cold, it also parts with all its hygrometric water, which is a more convenient method of operating in many experiments, as it does not require the presence of any foreign substance. So delicate a test of hygrometric moisture is the fluoboracic gas, that if only a fiftieth part of moist air be added to air hygrometrically dried, this added portion will be made sensible by a vapour on introducing a little of the gas.

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[a] Recherches Physico-chemiques, tom. ii.

By employing this gas as a test of hygrometric water, it was found that all the gasses insoluble (or nearly so) in water, were capable of containing a considerable portion of hygrometric water separable by the means above mentioned.

Some of the gasses soluble in water, such as oxymuriatic acid, carbonic acid, and sulphureous acid gas, also contain a portion of hygrometric water, but this must be always less in proportion to the solubility of the gas, since the contact of water constantly tends to make them assume the liquid state.

On the other hand, muriatic acid gas, even when procured by boiling liquid muriatic acid, and without being subjected to any drying process, gives no vapour whatever, either when exposed to intense cold, or to fluoboracic acid, and hence the authors infer, that muriatic acid gas contains no hygrometric water.

Nevertheless, these chemists assert that muriatic acid gas does actually contain a very large portion of water, which is not separable from it by those means that detach hygrometric water, but is absolutely essential to its constitution as long as it retains its gasseous form, and therefore, muriatic acid gas cannot be expelled from the dry muriats, unless sufficient water is present to unite with the gas as it forms, and to constitute about a fourth of its weight. The following experiments are given in support of this opinion.

A mixture of dry muriat of silver and melted boracic acid was strongly heated in a coated iron tube, but no gas was expelled, except the common air of the apparatus. On the other hand a similar mixture was heated in an iron tube, and when scarcely red-hot, some steam was passed through it from water boiling in a small retort connected with the apparatus. Immediately a large quantity of muriatic acid vapour was given out, the muriat of silver was completely decomposed, and only borat of silver remained.

Some charcoal previously ignited in a strong forge furnace was mixed with twice its weight of melted muriat of silver, and the mixture put into a porcelain retort and heated. When red-hot, a little muriatic acid and inflammable gasses were given out, but this soon ceased, and though the heat was raised so high as to soften the retort, no more gas was obtained. The greater part of the muriat of silver was found unchanged in the retort.

On the other hand, similar materials were heated in an earthen tube, and the steam of water was transmitted through them when scarcely red-hot, A great abundance of muriatic gas was expelled, and the silver was entirely reduced. The reason that some decomposition took place in the former experiment, was obviously owing to the great difficulty of expelling by mere heat every particle of water existing in charcoal; for charcoal not previously ignited when heated with muriat of silver, immediately disengages muriatic acid gas, and the silver is reduced.

Similar experiments were made with vitrified boracic acid, and fused muriat of barytes. Very little muriatic acid was obtained, and after the utmost effect of the fire, the boracic acid and the muriat of barytes were found in distinct strata nearly unchanged. On the other hand, the transmission of steam through the same materials, expelled all the muriatic acid at a low red heat, and the residue was borat of barytes.

The muriats of strontian, soda and lime gave similar results, the latter however produced rather more muriatic gas without the intervention of the water, owing probably to the very powerful attraction of the muriat of lime for moisture, which makes it hardly possible to expell the last portions by mere heat.

As a proof of the retention of some moisture by fused muriat of lime, as well as by vitreous phosphoric acid, and by charcoal and some other substances after being strongly ignited, it is found that when heated with clean iron filings, they all give more or less of hydrogen gas.

This action of water on the muriatic acid of the muriats is therefore so great, that the dry muriats which resist decomposition at the highest temperature by boracic or phosphoric acids, are readily decomposed by the same reagents, with the intervention of aqueous vapour at a very low red heat. Nor is this all, for, as will be presently mentioned, the dry muriat of magnesia formed by passing oxymuriatic acid over calcined magnesia will give up none of its acid by mere heat, but will readily yield it by the addition of aqueous vapour alone, without the assistance of any other base. This however is not the case with most other muriats, for these are not decomposed by water alone, though readily so by water and a fixed base.

The decomposition of muriat of soda by sand in this manner is interesting on many accounts, and possibly (as the authors observe) might afford an economical mode of obtaining the alkali from salt. Two parts of fine sand, and one of fused common salt were mixed and put into a porcelain tube and heated to redness. Steam was then passed through from a small retort of boiling water connected with the tube, and a great abundance of muriatic acid vapour escaped at the other extremity. This was kept up for five hours, at the end of which the vapours were still acid. On examining the contents of the tube when cold, they were found to be an uniform opake frit, tasteless and insoluble in water and acids, but readily dissolving with a little addition of alkali. It still contained some undecomposed salt, but perfectly combined and vitrified with the sand.

Though the soda was not in this experiment actually obtained separate, there is no doubt but that it had been sufficient to dissolve the sand by fusion. This fact may perhaps be of advantage to the glass-maker. The other earths will also furnish a means of detaching the acid from salt. Thus much muriatic acid is given out by calcining balls of clay and salt, as long as the clay retains any moisture.

Many of the metallic muriats equally resist decomposition without the intervention of water, and yield their acid when moistened. Some calomel and recently calcined charcoal were strongly heated *per se* in a tube, but without any effect; but when common unprepared charcoal was used and the heat scarcely reached a cherry-red, much muriatic acid was given out, and the mercury was entirely reduced. Corrosive sublimate had the same effect as calomel.

The next object of these chemists was to ascertain the proportion in which water enters into the composition of liquid or gasseous muriatic acid. For this purpose the following experiments were made: 60. parts of oxyd of silver were combined with 15. of muriatic acid gas, and 71.3 of fused muriat of silver were produced. Hence as fused muriat of silver parts with none of its acid at the temperature of fusion, it was concluded that the difference of weight between that of the oxyd of silver and acid gas employed, and that of the fused muriat of silver produced, (amounting to 3.7) was the amount of the water combined with the muriatic acid gas before its union with the oxyd of silver, and hence this acid gas contains about a fourth of its weight of combined water, though as already mentioned, no water can be extracted from it by the common means of freeing gasses from hygrometric moisture. Another computation was made in the following way. Oxyd of silver was prepared by adding pure potash to pure nitrat of silver, and it was dried at the heat of a boiling solution of muriat of lime. Some of this oxyd was separately heated *per se* till the silver was reduced, and it was afterwards found to contain no moisture, and by estimating the oxygen given out in the reduction, the oxyd was found to be constituted in the proportion of 100. of silver to 7.6 of oxygen. The oxyd being thus previously analyzed, a given weight was combined with a known weight of muriatic acid gas, and the fused muriat of silver resulting from the mixture being weighed, this salt was estimated to consist of

100.00	Silver
7.60	Oxygen
25.71	Muriatic acid

A given quantity of muriatic acid gas dissolved in water was then precipitated by nitrat of silver, and (estimating from the above data) muriatic acid gas was found to contain 24 per cent. of water, which nearly coincides with the former experiment.

A further proof of the existence of water in muriatic acid gas, is stated by these chemists to be furnished by the mutual action of hydrogen and oxymuriatic acid gas, and as the particulars of these experiments (whatever be the inference) are most interesting, we shall give them with some minuteness.

First to determine the specific gravity of oxymuriatic gas, a retort was partly filled with common salt, oxyd of manganese, and dilute sulphuric acid, and the oxymuriatic acid gas obtained by gently heating these materials was passed through a large quantity of dry muriat of lime, and thence through a tube, to the bottom of a dry matrass full of common air. As the acid gas is much heavier than common air, and as the tube dipped quite to the bottom of the matrass, in half an hour the whole of the common air was expelled, and the oxymuriatic acid gas had taken its place. The whole was then weighed, and by making the proper corrections, the specific gravity of the oxymuriatic acid gas was found to be 2.47 common air being 1. This experiment was repeated twice, the acid gas being analyzed afterwards in order to ascertain that it contained neither common air, nor carbonic acid.

Oxymuriatic acid gas was placed in contact with hydrogen in two modes, by ammonia, and by pure hydrogen gas.

In the former mode, a narrow necked matrass filled with oxymuriatic acid gas was dipped into liquid ammonia. In a few minutes the whole of the gas was decomposed, and in its place a quantity of azote was produced, equal to a third of the volume of the oxymuriatic gas.

Hence, as ammonia consists of one part in bulk of azote, and three of hydrogen, it follows that the oxymuriatic acid gas must have absorbed three times the bulk of the azote, or in this case, as much hydrogen as the acid gas itself: hence too (as two volumes of hydrogen unite with one of oxygen to produce water) the oxygen in the acid gas is inferred to be equal to half its bulk. As this experiment is attended with some risk of explosion, it is proper to use the liquid ammonia in a dilute state, to introduce but little of it at a time into the matrass, and not to shake them together.

The other mode of making the experiment is by mixing oxymuriatic acid gas and hydrogen gas, and exposing them with caution to the sun's rays. For this purpose a glass matrass was selected, the neck of which entered the neck of another balloon matrass of the same capacity, and was made to fit by grinding.

One of the vessels was filled with oxymuriatic acid gas, and the other with an equal volume of hydrogen, and they were brought in contact by thrusting the smallest neck into the larger, and the juncture was made still firmer by cement. This apparatus was exposed to the diffused solar light for two or three days, during which the greenish-yellow of the oxymuriatic acid gas gradually disappeared. The process was finished by putting the apparatus into the sun's direct rays for an hour or two. The apparatus was then opened under mercury, and no absorption took place, shewing that the bulk of the gasses remained the same, but on introducing a little water, the whole gas was immediately condensed into liquid muriatic acid, with the exception of a few remaining bubbles of gas, supposed to be the azotic impurity of the gasses employed.

Some care is required in making this experiment. If the mixed gasses are at first exposed to the direct rays of the sun, the whole detonates in a few minutes with a violent explosion. On the other hand, if the vessel is set in a perfectly dark place, no action whatever appears to take place in several days; so that if after this it is placed in a bright sunshine, it detonates as violently to all appearance as it would do on the first moment of mixture. To succeed therefore in this experiment, the vessel should be set in as light a place as possible, but protected from the direct sunshine, till the decomposition appears nearly compleated, and the peculiar colour of the oxymuriatic acid gas is gone, after which it may be as well to compleat the process by a few hours in the direct sunshine.

It appears therefore that one volume of oxymuriatic acid gas and one volume of hydrogen, produce by their mutual action two volumes of muriatic acid gas, without any other gas being generated, or any water deposited. The specific gravities of these gasses is given by the authors as follows: (common air being unity) viz. Oxymuriatic acid gas 2.47 Oxygen gas 1.1034. Hydrogen gas 0.0732.

Hence the absolute weight of 247 grains of oxymuriatic acid gas (supposing it to consist of equal volumes of oxygen and muriatic acid freed from water of composition) will be

Grains.	
55.17	Oxygen
191.83	Dry muriatic acid
247.00	grains of oxymuriatic acid gas

And adding to this 7.32 grains of hydrogen (being the weight of an equal volume of this gas) the muriatic acid gas produced will be 254.32 grains, and the oxygen and hydrogen of this will together amount to 62.49 grains, which is inferred to be in the state of water in union with the muriatic acid gas, and is 24.57 per cent. of its weight.

Since muriatic acid gas results from the union of oxymuriatic acid gas and hydrogen, it may be inferred that it contains exactly that proportion of oxygen and real acid sufficient to convert the metals into muriats, and it will be totally absorbed by those metals that have the strongest affinity for oxygen. Thus if clean iron turnings are heated to low redness in a gun-barrel, and muriatic acid gas is passed through, pure hydrogen gas is disengaged, and the iron is changed to muriat of iron. But it has been found by Richter and Gay Lussac, that in all similar metallic salts, the acid and oxygen bear the same proportions to each other; and hence the acid and oxygen must be in the same ratio in muriat of iron as in muriat of silver, or (from the analysis of the latter salt) as 7.60 oxygen to 25.71 acid. These therefore must be the respective quantities of oxygen and acid in muriatic acid gas, since it forms muriat of iron by simple union with this metal. On the other hand, the hydrogen is found by the experiment of hydrogen and oxymuriatic acid gas to be in the same proportion to the oxygen in muriatic acid gas as that which constitutes water, which for 7.6 oxygen will require 1.034 hydrogen$=$8.634 water: and if this (from the analogy with muriat of silver) requires 25.71 acid, the whole will constitute $25.71+8.634=34.344$ muriatic acid gas, of which the water constitutes almost exactly a fourth of the weight.

The next object of enquiry with these eminent chemists was to determine the action of dry oxymuriatic acid gas on various bodies. The constitution of this gas is assumed, as already mentioned, to be muriatic acid freed from its water of composition, in gasseous combination with its own volume of oxygen. It may be decomposed in its gasseous state in three ways: 1st, by those substances which absorb it entirely, such as the metals, sulphur, and phosphorus. 2dly, by those oxyds (earthy or metallic) which combine with the dry muriatic acid, and thus disengage the oxygen of the gas: and 3dly, by hydrogen or substances containing hydrogen, which by uniting to the oxygen of the oxymuriatic acid gas will furnish that quantity of water necessary to cause the muriatic acid to assume the gasseous form.

The first method of decomposing oxymuriatic acid gas is by placing it in contact with most of the metals, whence the metallic muriats are produced.

Sulphur also forms with oxymuriatic acid gas a compound first discovered by Dr. Thomson, and which is considered by Berthollet as a triple compound of muriatic acid, oxygen, and sulphur. Many of the metallic sulphurets furnish the same compound.

Oxymuriatic acid gas is also decomposed by phosphorus, and the result is a very singular compound which was first described by Sir H. Davy, who obtained it by heating phosphorus in the gas. It has been procured by the French chemists in the following manner: some phosphorus was put at the bottom of a glass tube closed at one end, and over it about double the weight of calomel. A gradual heat was applied, the phosphorus slowly sublimed through the calomel, and almost immediately the peculiar liquid in question was produced, which condensed in a small receiver adapted to the open end of the tube, but closed from the access of external air. This peculiar liquid is limpid, fuming, colourless, acid, and very caustic. When exposed to the air it is entirely decomposed, and phosphorus is deposited. Water partly dissolves it, and phosphorus separates. Potassium burns in it vehemently, and muriatic acid gas is formed. When this liquor is heated and its vapour passed through heated iron filings it is totally decomposed, no gas is given out, and the iron is changed to muriat and phosphuret of iron. Corrosive sublimate answers as well for obtaining this liquid as calomel.

The second method of decomposing oxymuriatic acid gas is by the action of some substance which absorbs the acid and allows the oxygen to escape. Lime answers this purpose. Some pure and strongly ignited lime was intensely heated in a porcelain tube, and dry oxymuriatic gas was passed through. The gas was almost totally decomposed, much oxygen gas was evolved, and the tube, when cold, was found to contain a fused mass of muriat of lime.

A similar decomposition took place by passing the gas through calcined magnesia; much oxygen was given out, and a dry neutralized muriat of magnesia remained. This muriat did not part with its acid at a very intense heat; but as soon as it was moistened it became similar to the common muriat prepared by dissolving magnesia in liquid muriatic acid; and like this it now yielded up its acid at a very moderate ignition.

The third mode of decomposing oxymuriatic acid gas is by hydrogen, either singly or holding sulphur, &c. in solution, or in the form of water. The decomposition by hydrogen alone has been fully described.

Sulphuretted hydrogen, mixed with oxymuriatic acid gas, gave an immediate deposition of sulphur, and muriatic acid gas was produced in equal volume to the gasses employed.

Phosphuretted hydrogen decomposed it with equal rapidity.

Carburetted hydrogen decomposed it only

after some days exposure to light, and charcoal was deposited.

The vapour of water and oxymuriatic acid gas were both together transmitted through a red-hot porcelain or luted glass tube, and the products were oxygen gas and liquid muriatic acid. When the tube was kept very hot and the vapour of the water was abundant in proportion to the oxymuriatic acid gas, scarcely a particle of the latter escaped decomposition.

The converse of these experiments, and what the authors consider as a proof of the justness of the theory derived from them, was the failure to decompose oxymuriatic acid gas by other substances in themselves greedy of oxygen, but either containing no hydrogen, and therefore not being able to produce water with the oxygen of the oxymuriatic acid gas, to enable it to become gasseous muriatic acid; or else, being of such a nature when oxydated as not to form chemical compounds with muriatic acid deprived of water. The substances employed were sulphurous acid gas, carbonic acid, nitrous oxyd, and nitrous gas, all carefully freed from hygrometric moisture; and these were mixed with equally dry oxymuriatic acid gas, and kept for several days exposed to light, but the green colour of the oxymuriatic gas was unaltered, and on shaking the mixture with mercury it was totally absorbed, leaving unchanged the gas with which it had been mixed.

The dry sulphites of barytes and lime were kept for five or six days in contact with dry oxymuriatic acid gas, but without any change; though on moistening them, the products were a mixed sulphat and muriat of the earth employed, and a disengagement of sulphureous acid gas.

We shall conclude our account of the experiments of Messrs. Gay Lussac and Thenard, by the short summary which they have given of the leading facts.

1. Oxymuriatic acid gas when singly exposed to the sun's rays, is not changed, but when it is at the same time in contact with water it disappears, and is converted into muriatic acid gas and oxygen.

2. Hydrogen gas and oxymuriatic acid gasses, in equal volumes, when exposed to solar light, combine into muriatic acid gas, without change of volume or deposition of water.

3. Pure charcoal has no effect on oxymuriatic acid gas at any temperature, but if it contains hydrogen muriatic acid gas is produced, and if it contains water, both muriatic acid gas and carbonic acid are generated.

4. Phosphorus absorbs oxymuriatic acid gas, and produces a peculiar liquid.

5. The same liquid is obtained by treating the muriats of mercury with phosphorus, and then the mercury is reduced, but no muriatic acid is disengaged.

6. Sulphur absorbs oxymuriatic acid gas, producing that peculiar compound first discovered by Dr. Thomson.

7. The metallic sulphurets have the same action as water.

8. All the metals will combine with oxymuriatic acid gas, and form thereby metallic muriats. Some of the metals, such as zinc and iron, are powerfully acted on by muriatic acid gas, and hence result metallic muriats, similar to those obtained from the oxymuriatic acid, but also with the production of as much hydrogen as the volume of muriatic acid gas absorbed.

9. None of these muriats can be decomposed by pure charcoal, by vitrified boracic acid, or by glass of phosphorus.

10. On the other hand, all these muriats may be decomposed by the above substances with the assistance of water, or by carburetted hydrogen, and hence by animal and vegetable substances. The metallic muriat with water and charcoal produces muriatic acid gas, carbonic oxyd, and the metal is reduced: the muriat with water and phosphoric acid, gives muriatic acid gas, and the metallic phosphat: the muriat with hydrogen gives muriatic acid gas, and the metal is reduced.

11. The muriats of barytes, strontian, lime, potash, soda, and magnesia, when quite dry; are not decomposed by the dry boracic and phosphoric acids, but are readily decomposed by them when moisture is present. Charcoal however in neither case decomposes them.

12. The muriats of glycine, yttria, alumine, zircon, and silex, would probably agree in properties with those last mentioned, if they could be obtained free from water.

13. When muriatic acid gas and dry oxyd of lead are mixed together at a moderately high temperature, the gas is absorbed, and muriat of lead and water are produced: the same result is obtained with the other metallic oxyds.

14. A similar result with the last is obtained by using barytes, strontian, and lime, instead of oxyd of lead.

15. Common salt cannot be decomposed at any temperature by sand or alumine, but is easily decomposed by either of them when

moistened. The same may be said of the muriats of barytes, potash, strontian, and lime.

16. Oxymuriatic acid gas, when in contact with liquid ammonia, disappears, muriat of ammonia is formed, together with azote, equal in volume to a third of the acid gas absorbed.

17. Sulphureous acid gas, nitrous oxyd, and nitrous gas, have no action on oxymuriatic acid when dry, but with contact of moisture the decomposition is sudden, and the above three gasses become oxygenated.

18. The dry sulphites have no action on oxymuriatic gas, but when moisture is admitted the action soon begins, sulphureous acid, a muriat, and a sulphat are formed.

19. When Libavius's liquor (or dry muriat of tin) is put in contact with ammonia over mercury the gas is absorbed, no other gas is given out, and a white solid is produced, which when heated, sublimes entire. Ammonia therefore will not separate oxyd of tin from this solution, unless water is added, and then the oxyd separates immediately.

20. When phosphorus is treated by oxymuriatic acid gas, a liquid and a solid compound are formed, which will unite to ammonia into a singularly fixed substance, but without obvious decomposition, unless water is added, in which case ammonia is expelled, and muriatic and phosphoric acids are produced.

21. Oxymuriatic acid gas absorbs thrice its volume of ammoniacal gas, a dry muriat of ammonia is produced, and azote about equal to a tenth of the entire volume is given out.

We shall now proceed to give some of the leading experiments on oxymuriatic acid and its compounds, from which the most original and inventive chemist of our own times has raised a theory that at present divides the chemical world.[b]

The opinion advanced by Sir H. Davy on the nature of these substances is, that oxymuriatic acid is a simple undecomposed substance containing no oxygen, but capable of combining with many bases into compounds, in many respects analogous to oxyds, and often giving out heat and light during the combination. To avoid confusion in this mode of considering the subject, and the impropriety of expressing in its name the presence of oxygen, the inventor of this theory has given to oxymuriatic acid the term *Chlorine*, derived simply from the green colour which it possesses when in a gaseous form. On the other hand, *Muriatic Acid* is a compound of chlorine and hydrogen in equal volumes, and contains no water of composition when in the form of gas.

Chlorine or Oxymuriatic Gas.

This substance is of a yellowish green colour, when gaseous. Its sp. gr. is to that of hydrogen, as 33.5 to 1. and 100 cubical inches at a mean temperature and pressure weigh 76 to 77 grains. Water at 60°. dissolves about double its volume of this gas. When an inflamed taper is introduced into a phial filled with it, the light continues, but of a dull red colour, and a dark carbonaceous smoke arises from the flame. Many of the metals introduced into it in thin leaves or in powder take fire, and burn spontaneously at a common temperature. Such are copper, tin, arsenic, zinc, antimony, potassium, and sodium. Phosphorus burns in it spontaneously with a pale white light, producing a white volatile powder. Sulphur melted in it does not burn, but forms with it a volatile red liquor.

Chlorine is not changed by the action of electricity if pure.

It is not altered by any action of heat or cold, but its aqueous solution freezes at about 40°. Fahr.

It is capable of holding hygrometric water in solution, which may be separated by muriat of lime.

Chlorine when quite dry does not change vegetable colours, but when moisture is present the colours are speedily destroyed or brought to a dull yellow.

Chlorine unites with oxygen forming a peculiar compound, which will be presently noticed.

When potassium is introduced into chlorine gas, a very vivid inflammation ensues, and a dry salt results, which is the same as fused muriat of potash. One grain of potassium absorbs about 1.1 cubic inch of the gas. If the potassium is first oxydated by combustion in oxygen gas, and the dry oxyd thus produced is afterwards gently heated in chlorine, as much oxygen is expelled from the oxyd as was at first absorbed by the potassium, and the residue is muriat of potash, exactly the same in quantity as would have been produced by the simple combustion of the potassium in chlorine. No water is produced in this experiment, provided care be taken to exclude the crust of potash on the surface of the metal; and hence the author explains it to be an example of decomposition of the oxyd of potassium by simple affinity, the chlorine uniting with the metallic base and the oxygen being expelled, Hence the author of the experiment considers the salt dry muriat of potash, to be in fact a compound of chlorine and potassium, which agreeably to the nomenclature he has adopted, he terms *Potassane*.

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[b] Davy, Elements of Chemical Philosophy. Phil. Trans. for 1809, 10, 11, 12.

When sodium is used similar appearances take place, chlorine is absorbed (but in nearly twice the quantity of that absorbed by an equal weight of potassium) all the oxygen united with the oxyd of sodium is expelled, and the compound *Sodane* is produced, which is identical with fused muriat of soda.

When sodane is heated with potassium, sodium is sublimed, and this furnishes the easiest method of procuring this metal.

Two parts of potassium furnish one of sodium.

When potassium is exposed to muriatic acid gas dried by muriat of lime, it immediately becomes covered with a white crust, no inflammation ensues, but the gas is totally absorbed, and if proper proportions of each substance be used, the whole of the potassium is changed to muriat of potash (as with chlorine and potassium), but with this difference, that when muriatic acid gas is employed, there is a gasseous residue consisting of hydrogen, amounting to a third of the volume of the muriatic gas employed.

The muriat of potash thus produced will furnish with nitrat of silver exactly the same weight of muriat of silver as the same quantity of muriatic acid gas simply absorbed by water, and then decomposed by nitrat of silver. This fact, which was at first brought forward as a proof of the existence of combined water in muriatic acid gas, will obviously admit of an equally consistent explanation on the hypothesis, that this gas consists of chlorine and hydrogen, and that the dry muriats are compounds of chlorine and the base, singly and not oxydated.

It has been stated that when the oxyds of potassium are heated in chlorine, muriat of potash (or the compound of chlorine and potassium) is produced, and as much oxygen is expelled as was before contained in the oxyd. The same takes place when the oxyds of barium, strontium, and calcium, (or in other words, the *earths* barytes, strontian, and lime) are heated with chlorine; the dry muriated earth is produced, and oxygen is expelled.

The compounds produced by the action of chlorine and phosphorus are peculiarly interesting.[c] If a small exhausted retort furnished with a stop-cock is filled with dry chlorine gas and some phosphorus added, the mixture kindles and burns with a white flame. The chlorine is totally absorbed, for when the stop-cock is opened, a fresh quantity of chlorine, nearly as much as would have filled the vessel, will enter. In this way, one grain of phosphorus will absorb nine cubic inches of chlorine. A white sublimate collects at the top of the vessel, and a limpid fluid trickles down the sides. The sublimate gives fumes of muriatic acid when exposed to air, and when moistened is converted to phosphoric and muriatic acids. This sublimate is a non-conductor of electricity, and when heated, sublimes unchanged at a less heat than boiling water: when touched with a lighted taper it inflames, and when passed through a red-hot glass tube with oxygen, phosphoric acid is produced, and chlorine is evolved. The vapour of this sublimate reddens dry litmus. It absorbs dry ammoniacal gas with much heat, and the result is a compound insoluble in water, without taste or smell, which is undecomposable by acid or alkaline solutions, and is not volatile at an intense red-heat in close vessels, but heated in the air it produces phosphoric acid. Sir H. Davy considers the sublimate as composed of 134 of chlorine to 20 of phosphorus, as deduced from the quantity of muriat of silver which it produces with nitrat of silver. He terms this sublimate *Phosphorana*.

It has been mentioned that along with this sublimate a limpid fluid is produced. This fluid is obtained in greater abundance by subliming phosphorus through a stratum of heated corrosive sublimate or calomel in a glass tube. It is a limpid colourless fluid of the specific gravity of 1.45. It emits acid fumes when exposed to *moist* air, but not to dry: and it does not redden litmus paper unless it be damp. The vapour arising from heating this fluid is highly combustible. When this fluid is put in contact with dry chlorine, it is converted to *phosphorana*, the last mentioned substance, and when in contact with ammonia, phosphorus is produced, and the same compound as that formed by phosphorana and ammonia. This fluid analyzed by nitrat of silver is composed, according to Davy, of 20 of phosphorus and 67 of chlorine. It has therefore only half the chlorine of the former compound, and is termed *phosphorane*.

Chlorine will unite with sulphur into a peculiar compound, which was first produced by Dr. Thomson, by passing chlorine over flowers of sulphur, and considered by him as sulphuretted muriatic acid. It is obtained also more expeditiously by heating sulphur in a retort filled with chlorine. The compound in question is a fluid volatile below 200°., and distills into the cold part of the retort. Its colour by reflected light is red, but yellowish green in transmitted light. It smokes when exposed to air. Its specific gravity is 1.6. It does not redden dry litmus. When water is added, it becomes turbid and strongly sour with sulphuric acid.

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[c] Phil. Trans. 1809 and 10. Davy's Elements.

Ten grains of sulphur absorb nearly 30 cubic inches of chlorine, which is nearly in the proportion of 30 sulphur to 67 chlorine. Considering this as a compound of sulphur and chlorine, Sir H. Davy calls it *Sulphurane.*

The appearances that take place on the union of chlorine and hydrogen have been already fully described. One volume of hydrogen unites to 1 volume of chlorine, or 1 *in weight* of hydrogen to 33.5 chlorine, and the product is 2 volumes of muriatic acid gas. This elementary experiment has been explained according to each theory of muriatic acid as has been already described.

Chlorine has no action whatever on carbon even when assisted by common ignition or by the most intense power of voltaic electricity, provided the chlorine be previously dried, and the charcoal ignited in a strong heat.

The action of chlorine on most of the metals is very powerful, many of them burning with a brilliant flame when introduced in a divided state into chlorine gas. The products vary considerably in consistence and sensible properties, being in some instances solid, in others forming dense fluids, which have been long known under the name of metallic butters.

Thus the *Butter of Arsenic* is produced by the action of chlorine on metallic arsenic; the *Butter of Antimony* by chlorine and antimony, &c. The compound of chlorine and mercury is corrosive sublimate; tin and chlorine furnishes that singular fluid called Libavius's liquor. If this liquor is confined in ammoniacal gas, the ammonia is absorbed with much heat, and a grey solid is produced, which when heated is entirely volatilized in very pungent fumes; ammonia therefore alone does not decompose this liquor, but when water is added a peroxyd of tin is deposited, and the liquid becomes a solution of muriat of ammonia. All the compounds of chlorine and of the metals are decomposed by water, the metal being partially separated in the form of oxyd and the liquid containing muriatic acid. This is explained by Sir H. Davy on the hypothesis, that the water is decomposed on the compound of chlorine and the metal, the oxygen of the water passing to the metal, and its hydrogen uniting with the chlorine to form the muriatic acid which is then generated.

The metallic *oxyds* are most of them acted upon by chlorine, but with great difference in the appearances. The oxyds of lead, silver, tin, copper, antimony, bismuth, and tellurium are decomposed in a heat below redness; the oxyds of cobalt and nickel require a red heat; the red oxyd of iron is not at all acted on, but the black oxyd is with ease: arsenical acid is not altered by being heated in chlorine, but the white oxyd is readily decomposed. In the cases where oxygen was given off, it was found to be pretty exactly the same as that which previously existed in the oxyd.

All these compounds have received new names in the author's nomenclature with the termination *ane;* the compound of silver and chlorine being *argentane;* butter of antimony, *antimonane,* &c.

CHLORINE AND OXYGEN. EUCHLORINE. This curious compound of chlorine and oxygen was discovered by Sir H. Davy in 1811.[d]

Chlorine prepared from pure oxyd of manganese is uniform in its properties, but the gas obtained by muriatic acid and the salts commonly called hyperoxymuriats, differs very much in its properties, according to the circumstances of its preparation. When much acid is employed to a small quantity of salt, and the gas is collected over water, the water becomes tinged of a lemon colour, but the gas is pure chlorine the same as that from manganese. But when the gas is collected over mercury, and is procured from a weak acid and a great excess of the salt by a low heat, its colour is a deep greenish yellow, and it possesses properties totally different from pure chlorine. This gas termed Euchlorine by the discoverer, is distinguished for the facility with which it explodes, often merely on being transferred from one vessel to another, and always by a very gentle heat, and hence it is not safe to operate on large quantities. By explosion in close vessels, it is resolved into chlorine and oxygen. This gas is partially decomposed by water, and oxygen is set free, but it is very little so by mercury.

On the other hand mercury readily absorbs pure chlorine, and therefore the two gasses may be separated by agitation with mercury, which forms corrosive subimate with any portion of chlorine with which the gas is mixed, and the euchlorine remains pure.

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[d] Ph. Trans. for 1811, and Davy's Elements.

Euchlorine is more yellow than chlorine, and its smell is like that of burnt sugar. Its specific gravity is to that of hydrogen as 33 to 1. and 100 cubic inches of it weigh from 74 to 75 grains. 50 parts of euchlorine after detonation expand to 60 parts, of which about 40 are chlorine and 20 pure oxygen, and hence it is composed of two parts in volume of the former to one of the latter, and the oxygen which it contains is condensed to half its volume.

Water takes up about 8 or 10 times its volume of euchlorine, but this cannot be again expelled without decomposition.

When euchlorine is detonated with twice its volume of hydrogen, there is an absorption of more than $\frac{1}{3}$, and a solution of muriatic acid is formed: when the euchlorine is in larger proportion there is also an evolution of oxygen.

None of the metals that burn in chlorine act upon euchlorine at common temperatures, but when the oxygen is separated, or when the heat is raised, they then inflame.

Thus let a vessel be exhausted and filled with euchlorine and some brass foil introduced, and no action will ensue, but on passing up a little nitrous gas the oxygen is removed, and then the chlorine begins to act upon the brass and inflame it.

Phosphorus explodes in euchlorine, and the product is phosphoric acid and oxymuriat of phosphorus or *phosphorane*.

When euchlorine is mixed with muriatic acid gas there is a gradual diminution of volume, chlorine gas is formed, and a dew appears on the sides of the vessel.

Euchlorine even when freed from hygrometric water reddens vegetable blue colours and then destroys them, which circumstance, together with its absorbability by water, and the acrid taste of its solution would lead to the opinion that euchlorine has somewhat of an acid nature.

Chlorine and Azote. A very peculiar compound of these two elements, which appears to be one of the most powerful detonating substances hitherto known, is described under the article *Azotized oxymuriatic acid.*

Chlorine and Carbonic Oxyd. Some facts relating to the mutual action of these substances have been observed by Mr. John Davy, which require a short notice.[e]

When equal volumes of these gasses (both perfectly dried by fused muriat of lime) are mixed together in an exhausted glass globe, with a stop-cock, and every precaution taken to exclude moisture, and exposed for about a quarter of an hour to bright sunshine, the colour of the chlorine disappears, and on opening the stop-cock over dry mercury, an absorption of one half of the original bulk takes place, and the remaining gas is a peculiar compound to which Mr. J. D. gives the name of *Phosgene Gas.* This gas is intolerably pungent and suffocating, and reddens litmus. Its specific gravity, inferred from that of its constituent parts, is very great, so that 100. cubic inches weigh 105.97 grains.

Water rapidly changes this gas into the carbonic and muriatic acids. Many of the metals heated in this gas entirely decompose it, though without ignition or explosion in any instance: a compound of the metal and chlorine is formed, and the carbonic oxyd remains unaltered, and then resumes its original bulk, which is equal to that of the entire gas before decomposition. Sulphur and phosphorus sublime in the gas unaltered. This gas is remarkable for the large quantity of ammoniacal gas which it condenses, being as much as four times its volume. The product is a white neutral salt of a pungent saline taste, effervescing with the strong acids, and giving out muriatic and carbonic acid.

The nature of this ammoniacal compound is somewhat doubtful, and has been the subject of controversy between Mr. J. Davy and Mr. Murray, but it is not doubted that chlorine and carbonic oxyd mixed together and exposed to the sun's rays, do really combine into the very dense gas described by Mr. J. D. whose properties are different from those of any other known gaseous compound.

Muriatic Acid Gas and Ammonia. It has been already observed that most of the facts relative to the chemical action of muriatic and oxymuriatic acids may be explained with equal plausibility, either on the hypothesis that dry muriatic acid gas consists of muriatic acid and water of composition; that the dry muriats consist of the oxydated base united to muriatic acid alone, excluding the water of composition; and that oxymuriatic acid consists of muriatic acid and oxygen, also excluding water of composition: or else on Sir H. Davy's hypothesis that oxymuriatic acid (chlorine) is a simple substance; that the dry muriats consist of the base, not oxydated, and of oxymuriatic acid; and that muriatic acid gas consists of oxymuriatic acid and hydrogen.

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[e] Phil. Trans. for 1812.

Therefore when water is produced by the union of muriatic acid gas and any *oxyd*, it may either be said that the water is simply expelled from the muriatic acid gas whilst uniting with the oxyd; or else that it is produced by the union of the oxygen of the oxyd with the hydrogen of the muriatic acid, whilst the base of the oxyd and the chlorine of the muriatic acid form the compound usually (but on this view incorrectly) termed a muriat. It would therefore be a decisive experiment as to the source of the water so produced, if it made its appearance when muriatic acid gas was united to some base that contained no oxygen, as in this case the water, or at least its oxygen, must of course proceed from the muriatic acid gas. Mr. Murray has therefore proposed as an *experimentum crucis* to combine dry muriatic gas with dry ammoniacal gas, since ammonia is not generally supposed to contain oxygen, and to examine carefully whether any water is condensed during the experiment.

This experiment has been performed apparently with great care, both by Mr. Murray who first proposed it, and by several other chemists, but with very differing results. We shall therefore not dwell upon the particulars at present. On the whole it appears that more difficulties than were at first supposed stand in the way of very accurate results When the two gasses are mixed together, a very dense white cloud immediately appears, and if the gasses are pure and in proper proportions, they totally combine into a flocculent saline crust of muriat of ammonia. Some drops of water seldom fail to appear, but from the very volatile nature of the salt obtained, it is by no means easy to devise any unexceptionable mode of determining its actual dryness, or of expelling every particle of water that it may contain, with the same certainty that it may be expelled from the muriats of potash, of soda, or of any other fixed base. It must however be borne in mind, that the quantity of water thus produced should be considerable, in order to establish its source to be the muriatic acid gas, since this gas is inferred by all the experiments that are explained on this hypothesis to contain full one fourth of its weight of water.

Muriatic Acid. The following estimation of the strength of solutions of muriatic acid gas in water of different specific gravities may be of practical utility.[f] The specific gravity of muriatic acid gas is to that of hydrogen nearly as 17 to 1. 100 cubic inches of it weigh at a mean temperature and pressure between 39 and 40 grains. Water at 40°. absorbs about 480 times its volume of the gas, and then forms a liquid muriatic acid of 1.2109 sp. gr., and 34.8 grains of muriatic acid gas dissolved in water and the solution precipitated by nitrat of silver will give about 132 grains of dry luna cornea, equal to 379.31 grains of luna cornea from 100 grains of muriatic acid gas.

At 45°. therm. and 30°. bar. 100 grains of liquid muriatic acid of 1.21 specific gravity contain about 42.42 grains of muriatic acid gas; and 100. grains of acid at 1.01 specific gravity contain 2.02 grains of acid gas. Hence in liquid muriatic acid at the above temperature and pressure, for every encrease of .01 specific gravity above unity, a corresponding encrease of 2.02 grains of muriatic acid gas in 100 grains of the liquid acid may be allowed, if the above data are accurate. Thus for example, 100. grains of liquid acid at 1.15 specific gravity, will contain $2.02 \times 15 = 30.3$ grains of muriatic acid gas: and 2.02 grains of the acid gas will produce 7.662 grains of dry luna cornea.

We shall conclude this article with a short account of some further experiments undertaken by Dr. Henry, on the action of electricity on muriatic acid gas.[g]

The general accuracy of the former experiments is amply confirmed by the present series, but some slight corrections are required.

Dr. H. finds on the most careful examination, that under equal circumstances, precisely the same relative proportion of hydrogen gas is obtained from muriatic acid gas, whether it is or is not exposed to muriat of lime, which would shew that the latter gas is absolutely free from all hygrometric moisture.

The changes produced by electrifying muriatic acid gas *over mercury*, are a contraction of the volume of the gas, the formation of calomel and the evolution of hydrogen. But there is a natural limit to the decomposition of the same portion of gas by electricity, for by continuing the shocks, the action gradually diminishes, and after a time entirely ceases, though much of the muriatic acid gas remains undecomposed.

On the other hand, when muriatic acid gas is electrified in a close vessel, and not in contact with mercury, the same partial decomposition goes on, and hydrogen and oxymuriatic acid gas are produced, but as no mercury is in contact with the gasses, the oxymuriatic acid remains in the gasseous state, and therefore no diminution of bulk in the electrified gasses takes place

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[f] Phil. Trans. for 1812.

[g] Phil. Trans.

No water is condensed in either case. After an experiment of this kind, Dr. H. found on admitting water to the vessel containing the electrified gasses, and thus absorbing the unchanged muriatic acid gas, that the residue consisted of 100. measures of oxymuriatic gas, and 140 of hydrogen. These proportions widely differ from those that might be expected, from the fact that oxymuriatic acid and hydrogen unite in equal volumes to form muriatic acid gas; but the author shews that some of the deficiency in the oxymuriatic acid gas may be accounted for by being absorbed by the water employed to remove the muriatic acid gas. In making the experiment in a closed vessel, the greatest proportion of hydrogen obtainable by any continuance of the electrization, amounted only to about $\frac{1}{70}$th of the muriatic gas employed; while by electrization over mercury, from $\frac{1}{14}$ to $\frac{1}{16}$ of hydrogen was generally evolved. The author supposes this difference to arise from the circumstance of the mercury, when in contact with the electrified gas, removing the oxymuriatic acid as fast as it is formed, and in fact none of this acid is found in any other form than united with the mercury as calomel. Upon any theory of the constitution of muriatic acid, (Dr. H. observes) it may be expected that when in a mixture of that acid gas with hydrogen and oxymuriatic gasses confined in a close vessel, the two latter come to bear a certain proportion to the former, they will be brought within the sphere of mutual agency, and will reproduce muriatic acid. This point appears to be attained when the hydrogen and oxymuriatic acid taken together have the proportion to the muriatic acid of about 1 to 35. Beyond this point the evolved gasses appear to re-act on each other, and reproduce muriatic acid gas, so that no further products of the decomposition of the muriatic acid are obtained by any continuance of the electrization on the same materials.

But where the oxymuriatic gas is removed by the contact of mercury as fast as it is formed, this cause of the limitation of the action of electricity does not exist. The cause is suggested by Mr. Dalton to be the presence of hydrogen alone; and in consequence Dr. Henry mixed 30 measures of hydrogen with 400 of muriatic acid gas, and passed 900 electric discharges through the mixture without the least apparent effect, none of the mercury with which the gas was confined being changed into calomel, and the hydrogen and muriatic acid gas being recovered unaltered after the end of the process.

When muriatic acid gas and oxygen are electrified together in a close vessel, water is deposited in drops on the inner surface of the vessel, in the form of liquid muriatic acid, owing to its union with a portion of this acid gas. When the stop-cock of the vessel is opened under mercury, a quantity of this metal rushes in, and has its surface instantly tarnished by the oxymuriatic acid generated. Indeed the production of this latter acid takes place merely by letting muriatic acid gas and oxygen remain together for some time over mercury; the volume of the gasses contracts, and calomel is formed on the surface of the metal.

All these facts are equally to be explained by either theory of the constitution of muriatic acid.

N

NADELERZ. See Bismuth.

NEPHELINE, H. Sommite, K.

The colour of this mineral is semitransparent greyish-white. It occurs usually in small hexahedral prisms either regular or replaced on the lateral edges, sometimes also in disseminated grains. The lateral edges are smooth and shining with a vitreous lustre. The longitudinal fracture is more or less foliated; the cross fracture is conchoidal. Its hardness is about equal to that of glass. Sp. gr. 3.27.

By the long continued action of the blowpipe it melts into a compact glass. A semitransparent fragment being digested in cold nitric acid acquires a nebulous opacity. It is composed, according to Vauquelin, of

46.	Silex
40.	Alumine
2.	Lime
1.	Oxyd of iron
98.	
2.	loss

It has hitherto been only met with lining the cells of certain lavas of Monte Somma, and is usually accompanied by Idocrase.

NICKEL.

A very long and minute account of this metal in a variety of its combinations has been published by M. Tupputi,[a] being the result of experiments made under the eye of M. Vauquelin, and with the assistance of this eminent chemist. Some particulars of M. Tupputi's valuable memoir may be here given.

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[a] An. Ch. lxxviii. p. 133. lxxix. p. 153.

Pure Nickel. This was obtained from *Speiss*, a compound residue of the Saxon ores of cobalt and nickel, containing sulphur, much arsenic, iron, copper, cobalt, nickel and a little manganese.

The ore was first dissolved in hot dilute nitric acid, and the solution evaporated considerably, by which most of the oxyd of arsenic was separated on cooling in the form of white crystals. The clear hot liquor was then slowly saturated with carbonat of soda, which first separated a yellowish-white arseniat of iron, followed by a rose-coloured precipitate of arseniat of cobalt and some nickel, which was succeeded by a pale green arseniat of nickel. When this began to appear, no further alkali was added, but the liquor (still acidulous) was diluted and a current of sulphuretted hydrogen gas was passed through, which after some time separated the arsenic in the form of yellow sulphuret. The clear liquor, which now contained only nitrat of nickel and excess of nitric acid, was decomposed by an alkali, and the pure oxyd of nickel was washed and dried.

This oxyd was then mixed with about 3 per cent. of pitch and reduced in a crucible lined with charcoal exactly in the same way as the reduction of the oxyd of manganese is accomplished, and with an equal intensity of heat.

The button of metallic nickel is of a colour between silver-white and steel-grey, sp. gr. 8.38 increasing to 8.82 after being forged, and scarcely less magnetic than iron. It is very considerably ductile and malleable, though it contains a little charcoal, which appears when the pure metallic part is dissolved by an acid.

Oxyds and Hydrats. 100 parts of nickel dissolved in nitric or muriatic acid, precipitated by a fixed alkali and calcined, give 127 parts of a blackish ash-grey insipid oxyd. This is the base of most of the salts of nickel in acids, and is the *suboxyd* of nickel.

The *Peroxyd* of nickel, first discovered by Thenard, is easily prepared by passing oxymuriatic gas through the suboxyd when just precipitated and diffused in water; or by shaking the wet hydrat of nickel with a solution of oxymuriat of lime. This peroxyd is black, and gives out oxygen when it dissolves in sulphuric, nitric, or muriatic acids.

When a pure alkali is added to the salts of nickel, or when the solution of carbonat of nickel in ammonia is heated, a greenish white bulky granular *Hydrat* of nickel is separated, 100 parts of which lose 24 of water by low ignition, leaving 76 of the suboxyd.

Sulphuret of Nickel is easily formed by melting sulphur with metallic nickel or with the dry oxyd. It is brass-yellow, soluble in acids, and unmagnetic.

Nickel is not separated in its metallic state from its solutions by the addition of any other metal. Zinc alone troubles these solutions, and precipitates a little oxyd of nickel when there is no excess of acid; but when there is, a soluble triple salt of nickel, zinc, and the acid employed is produced, and the liquid remains clear.

Sulphat of Nickel. Sulphuric acid, when concentrated, hardly acts upon metallic nickel, but when diluted dissolves it with great ease, giving out much hydrogen and leaving untouched the small portion of carbon which the metal always contains. This solution forms green crystals of sulphat of nickel of the form of a rectangular prism, of a sweet and astringent taste, soluble in thrice its weight of cold water, and efflorescent when kept in the open air. A hundred parts of this salt lose in a red heat 55 parts of water along with a little acid, so that the calcined residue gives a blue to litmus. The oxyd of nickel in 100 of the crystallized salt is 25.63, leaving 29.37 for the acid.

Nitrat of Nickel. Nitric acid of any degree of strength dissolves nickel with ease, giving out much nitrous gas. The crystals of the salt are octagonal prisms, blueish-green, soluble in two parts of cold water and also in alcohol. When heated to redness it becomes yellow and olive coloured, loses acid, and is then a nitrat with excess of base, or a *subnitrat*. By continuing the heat the pure oxyd alone is left.

Muriat of Nickel. This metal dissolves readily in muriatic acid, forming when concentrated a confusedly crystallized mass of an apple green colour, soluble in less then twice its weight of water and also in alcohol. This last solution burns with a pale blue flame, passing to green as it becomes concentrated.

Phosphat of Nickel. The phosphoric acid when dilute dissolves nickel with ease, but this phosphat being insoluble, it is difficult to saturate the acid in this manner. The phosphat is made with perfect ease by any of the soluble salts of this metal and the phosphat of soda. Phosphat of nickel is green, nearly insipid, soluble in an excess of its own or of many other acids, but not in water.

Borat, Carbonat, Arseniat of Nickel. These salts are best formed by double decomposition. They are insoluble in water.

Chromat of Nickel. The chromic acid alone forms with the hydrat or wet carbonat of nickel a yellowish red solution, which however does not crystallize. Nitrat of silver added to it gives large red flocculi of chromat of silver. The alkalies all produce a yellowish red precipitate, probably a mixture of the oxyds of chrome and nickel.

Nickel has a peculiar tendency to form triple salts, so that a *sulphat of potash and nickel* is readily formed by evaporating a mixture of the two sulphats, and in like manner a *sulphat of ammonia and nickel*, a *sulphat of zinc and nickel*, and other triple salts may be produced.

Nickel and Ammonia. The hydrat of nickel dissolves with ease in liquid ammonia. The liquid is at first violet, but passes to a deep blue in proportion as the alkali becomes saturated. This solution when exposed to the air lets fall green flocculi, which are the triple *carbonat of ammonia and nickel*, as Proust first observed. The colour of the ammoniacal solutions of nickel is blue, but that of the neutral salts of nickel is green, and as most of the soluble salts of this metal contain a slight excess of acid and strongly tend to form triple combinations, the addition of ammonia to them does not at first disturb the green colour, but the blue begins to prevail when this alkali is in excess.

Sulphuretted Hydrogen, either gasseous or liquid, has but little action on the solutions of nickel in the mineral acids. A current of this gas passed through the liquid hardly renders it turbid. But on the other hand if the acid is vegetable, (the acetite of nickel for example) the solution is rapidly and almost entirely precipitated by the gas, leaving the clear liquor nearly colourless.

The author gives the following rules for determining the purity of metallic nickel.

It should dissolve totally in muriatic acid, except the small alloy of carbon which it has acquired during its reduction.

The solution, after the excess of acid has been driven off by heat, should give a yellow stain to paper when heated.

Prussiat of potash should give a yellowish white precipitate passing to green, and this should dissolve totally in ammonia into a dusky rose-coloured liquid, copiously depositing shining crystalline plates of a dun red colour when viewed by refracted light. When the ammoniacal solution is supersaturated with an acid, the liquor should not be troubled either by iron or by sulphuretted hydrogen, or by a further addition of ammonia; only this latter alkali, when it predominates, will give the whole a blue colour.

The muriatic solution when diluted with water should give white flocculi on adding tincture of galls, which are directly redissolved by an excess of the precipitant; but on adding much ammonia, a copious dun yellow precipitate will appear.

The metals with which nickel is usually alloyed are iron, copper, cobalt, bismuth and arsenic.

Iron will be detected by a blueish green precipitate insoluble in ammonia on adding prussiat of potash; or by a fine purple one on adding an excess of ammonia, followed by tincture of galls.

Copper will be shewn by a peach-flower precipitate on adding prussiat of potash, which is totally soluble in ammonia.

Cobalt is distinguished by forming a green sympathetic ink when heated.

Bismuth will be immediately blackened by sulphuretted hydrogen gas.

Arsenic will be deposited as a yellow hydrosulphuret by the same reagent.

To this account of some of the leading properties of pure nickel we may add some particulars on a very difficult problem in analytical chemistry, the compleat separation of cobalt from nickel contained in the same solution. These experiments are given by Hisinger and Murray,[b] in an examination of a supposed new metal, *Niccolanum*, announced by Richter, but which appears to be an alloy of nickel, cobalt and iron.

The presence of cobalt with nickel being suspected, Thenard's method of separating them by first bringing them to a high degree of oxidation and then adding ammonia was tried. The nitric solution of the mixed metals was exactly saturated with caustic potash and the blue-green precipitate, while still wet, was shaken in a phial containing a solution of oxymuriat of lime. This blackened the precipitate, which was then well washed to separate all adhering oxymuriat of lime, and was afterwards thrown into caustic ammonia. A deep blue solution, without any mixture of red or garnet tinge was formed, and after digestion for some days, the blue liquid was poured off from the undissolved oxyd. The liquid evaporated to dryness left a green oxyd, black when ignited, which dissolved before the blowpipe in phosphat of soda into a bead, blood-red when hot, but honey-yellow when cold, which was pure oxyd of nickel. So far the process answered well, but the oxyd remaining undissolved by the first portion of ammonia, now gave a *reddish* blue solution with fresh ammonia, which was found by further examination to be owing to the presence of a portion of cobalt along with the nickel.

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[b] Annals of Philosophy, No. 2.

It therefore appears probable that the per-oxyd of cobalt loses oxygen by digestion in ammonia, and *then* becomes soluble in some degree in this alkali.

The method of separating these two oxyds which these chemists adhere to is that of Proust, namely, to saturate the mixed ammoniacal solution with sulphuric acid, and by careful evaporation to obtain deep green crystals of sulphat of ammonia and nickel, while the sulphat of cobalt is left as a confused mass of a rose red colour. The green crystals may then be picked out from the red salt, and each decomposed separately.

NITRIC ACID, &c.
NITROUS GAS. } See Azote.
NITROUS OXYD.

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OIL. Fixed.

It is generally asserted that the fixed oils are insoluble in alcohol in their natural state, but as we have mentioned under the articles Oil and Soap (Chem. Dict.), when a fixed oil has first been chemically united to acids or to alkalies, and then separated by substances that have a stronger affinity to them, it becomes so much altered as to be often abundantly soluble in alcohol, and also in ether. But it has been found by careful experiments that all the fixed oils, even in their natural state, are in some slight degree soluble in highly rectified alcohol, and one of them, viz. castor oil, dissolves in this liquid in great abundance. This was first noticed by Rose, and afterwards by Bucholz.[a] Castor oil mixes with highly rectified alcohol in every proportion. Oil of almonds requires for solution about 30 parts of alcohol; linseed oil 20 parts; poppyseed oil 30 parts, &c.

Mr. Brande in his examination of a vegetable wax lately imported from Brazil, has the following observations on the solubility of the fixed oils in alcohol and ether.[b]

Four fluid ounces of sulphuric ether of .7563 sp. gr. dissolved $1\frac{1}{4}$ fluid oz. of oil of almonds, $1\frac{1}{2}$ oz. of olive oil, $2\frac{1}{2}$ oz. of linseed oil, and mixes uniformly with any proportion of castor oil.

Four fluid ounces of alcohol of .820 sp. gr. dissolve 1 fluid dram of linseed oil; and mix uniformly with any proportion of castor oil. But the action of alcohol on these oils is extremely lessened when the spirit is diluted, so that common spirit of wine has but little action even on castor oil. Camphor which so much assists the solubility of some of the resins in alcohol, has a similar effect on castor oil, which is abundantly soluble in spirit of .840 sp. gr. when previously combined with an eighth part of camphor. The other fixed oils however are not rendered more soluble by this means.

Water separates all these oils from their alcoholic solution, first making a milky liquor, after which the oil gradually collects on the surface in its original state.

With regard to the oil separated from soap by an acid, Mr. Haussman asserts that it thus acquires the power of acting upon bitumen, asphaltum and copal.[c]

OIL ESSENTIAL.

For some further experiments on the relation of essential oil with camphor, see Camphor.

OLEFIANT GAS. See Carburetted Hydrogen.

OSMAZOME. See Brain.

OXALIC ACID. Oxalats.

We have to notice some very interesting experiments on the composition of this acid and of its compounds. Those of Dr. Thomson[d] are peculiarly so, both from the skill and pains shewn in the analysis itself, and from the happy illustration of the Daltonian system which he has deduced from the composition of this acid. Part of this subject, together with Dr. Wollaston's additions, have been already noticed in the article *Affinity*, of this Appendix. The practical part and the general results remain to be mentioned.

The quantity of water of crystallization in oxalic acid was found by first adding to a solution of muriat of lime so much of a solution of crystallized oxalic acid as exactly separated the whole of the lime; then drying the oxalat of lime on a sand-bath at a heat between 200° and 300°; and then calcining the oxalat in an open platina crucible till nothing but pure lime remained. This gave the composition of the oxalat of lime, and hence the quantity of oxalic acid used in its production, and hence the difference of weight between the real or dry oxalic acid in the oxalat and in the crystallized acid employed, or in other words, the water of crystallization. In precipitating the lime from the muriatic solution by the oxalic acid it is necessary from time to time to saturate the excess of free muriatic acid in the supernatant liquor, which otherwise would dissolve part of the oxalat of lime and vitiate the result.

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[a] Ann. Chim. tom 69.

[b] Phil. Trans. for 1811. p. 265.

[c] Ann. Chim. tom. 58. p 185.

[d] Phil. Trans. for 1803

Exactly the same composition of oxalat of lime as that found in this manner was obtained by the direct combination of oxalic acid and lime-water. In both the dried salt consisted of 62.5 of acid, and 37.5 of lime.

The composition of the oxalats of the alkalies and of the alkaline earths was ascertained (with all except magnesia) by the direct union of the acid and base, always estimating the proportion of water of crystallization in the acid as the same with that found by means of the dry oxalat of lime. These oxalats were dried in the same manner, and it was inferred that little or no water of crystallization adhered to any of these salts after drying, except to the oxalat of potash, which Dr. T. conjectures to retain as much as 10 per cent. The oxalat of magnesia, on account of the great insolubility of this earth, was formed by the addition of oxalat of ammonia to sulphat of magnesia. It is remarkable that though the oxalat of magnesia is apparently equally insoluble in water as oxalat of lime, no turbidness appears on adding oxalat of ammonia and sulphat of magnesia till the liquor is much reduced in bulk or heated, or till they have stood together for some hours. When the oxalat of magnesia is once obtained, in either of these ways, or else by entire evaporation of the mixture and adding water to dissolve out the sulphat of ammonia, it is a tasteless insoluble powder.

Oxalat of ammonia crystallizes in long prisms. It requires more than 20 parts of cold water for its solution.

The exact composition of these oxalats we shall give presently, as well as the result of the author's experiments on the ultimate analysis of oxalic acid.

The composition of the oxalats and superoxalats has also been examined by Mr. Berard,[e] the results of which have a tolerable agreement with those of Dr. Thomson, though with some considerable deviations. M. Berard has also more particularly examined the superoxalats which are but little noticed by Dr. T.

M. Berard also takes the composition of the dry oxalat of lime as the basis of his calculations, and he gives almost exactly the same proportions in this salt as Dr. T. does, namely, 62 per cent. of acid, and 38 of lime. He also finds that the acid which sublimes unchanged in the dry distillation of crystallized oxalic acid is oxalic acid nearly as free from water of crystallization as it exists in the dried oxalat of lime.

We shall not enter into all the particulars of these experiments, but shall give the results. The crystallized oxalic acid employed for combination with the several bases contained 27.3 per cent. of water: that of Dr. Thomson contained 23. per cent but as the composition of the dry oxalat of lime was nearly the same in each, this difference in the acid does not affect the result.

	Acid.	Base according to Dr. Thomson	Base according to Berard
Oxalat of Ammonia	100.	34.12	38.2
——— Magnesia	100.	35.71	37.6
——— Soda - -	100.	57.14	69.7
——— Lime - -	100.	60.00	61.2
——— Potash -	100.	122.86	102.7
——— Strontian	100.	151.51	119.5
——— Barytes -	100.	142.86	164.3

The composition of the superoxalats was as follows in M. Berard's experiments, compared with the corresponding neutral oxalats:

Superoxalat of Potash was formed by crystallizing a mixture of the neutral oxalat of potash with an excess of acid. It is less soluble than the neutral salt. Ten parts gave by ignition 4.910 of fused carbonat of potash, of which the alkali was 3.46: and ten other parts of the same superoxalat decomposed by muriat of lime gave 10.6 of oxalat of lime, containing 6.58 of oxalic acid. Hence this superoxalat contains 65.8 of acid, and 34.2 of base.

Quadroxalat of Potash. This salt, discovered by Dr. Wollaston, may be formed either by adding more oxalic acid to the superoxalat, or by boiling a solution of muriat of potash with oxalic acid. This quadroxalat is less soluble than the two other salts of oxalic acid and potash. Analyzed in the way abovementioned it gave,

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[e] Ann. Chim. tom. 73.

18.95	Potash
72.05	Oxalic Acid
9.00	Water
100.00	

Hence the respective quantities of oxalic acid saturating 100 parts of potash in these three oxalats are,

In the neutral oxalat of potash	97.6
In the superoxalat . .	192.
In the quadroxalat . .	381.

which numbers are nearly in the rates of 1, 2, and 4.

The superoxalat is known more commonly as the *Salt of Sorrel*, and is used under this name in many parts of Europe. M. Berard mentions, that sometimes the quadroxalat is met with as salt of sorrel of the shops.

The *Oxalat of Soda* is but little soluble in water, and contains 143.3 of oxalic acid to 100 of soda.

The *Superoxalat of Soda* contains 284.7 of acid to 100 of soda, which is almost exactly thrice the quantity of that in the oxalat. This superoxalat is still less soluble in water than the oxalat, and may be formed either by the direct combination of the oxalat and oxalic acid, or by the action of oxalic acid on muriat of soda. The author could not produce any quadroxalat.

Oxalat of Ammonia. The composition of this was determined by saturating oxalic acid with liquid ammonia, which, according to Berthollet, at .9656 specific gravity, contains 8.761 per cent. of pure ammonia. The *Superoxalat of Ammonia* contained nearly a double proportion of acid.

Both an *Oxalat of Barytes* and a *Superoxalat of Barytes* exists; in the former of which 100 of barytes combine with 60.84 of oxalic acid; and in the latter with 123. of the same acid. This superoxalat is formed by boiling muriat of barytes with oxalic acid, which deposits the superoxalat in crystals on cooling. This compound is decomposed by mere boiling with water, which abstracts the excess of acid and reduces it to the simple oxalat.

The author has found no *Superoxalat of Strontian*, and the composition of the oxalat is given differently from that of Dr. Thomson, as will be seen by the table. M. Berard states that the oxalat of strontian which separates from the muriat of strontian with neutral oxalat of ammonia, is very little soluble, and the supernatant liquor remains equally neutral as before, which is a proof that the oxalat of strontian is itself neutral.

Ultimate Analysis of the Oxalic Acid. This was performed by Dr. Thomson, by the destructive distillation of perfectly dry oxalat of lime, and by analyzing all the gasseous products. The particulars of this analysis we shall not give, as the general mode, together with the difficulties that oppose a very accurate result, have been described under the article *Carburetted Hydrogen.* The general result is, that dry oxalic acid consists of

Oxygen -	64
Hydrogen -	4
Carbon -	32
	100.

taking this in round numbers.

Professor Berzelius gives the composition of oxalic acid somewhat differently[f] as to the proportion of hydrogen, being 35.02 of carbon, 0.68 of hydrogen, and 64.30 of oxygen. But the dry oxalat from which he formed his calculation was that of lead, which appears to have retained a much less proportion of the oxalic acid than the lime, since Professor B. reckons the crystallized acid to contain as much as 42 parts per cent. of water of crystallization; or, in other words, when 100 parts of the acid are boiled and evaporated to dryness along with pure oxyd of lead, the latter receives from the acid an addition of only 58 parts.

Lastly, the composition of oxalic acid is estimated by Gay Lussac and Thenard, by means of deflagration with oxymuriat of potash, to consist of

Oxygen -	70.69
Hydrogen -	2.74
Carbon -	26.57

which, supposing all the hydrogen to take as much oxygen as would convert it into water, would make, instead of the above quantities of these two substances, 22.87 of water, and 50.56 of oxygen in excess. These chemists employed the dry oxalat of lime as the form in which the dry oxalic acid may be exhibited, and they give the composition of this salt to be 61.345 of acid, and 38.655 of lime, which agrees very closely with the numbers given for this salt, both by Dr. Thomson and M. Berard. (See the article ANALYSIS *Vegetable and Animal*, in this Appendix).

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[f] Ann. Chim. tom. 81, p. 300.

OXYCARBURETTED HYDROGEN. See CARBURETTED HYDROGEN.

OXYMURIATIC ACID. See MURIATIC ACID.

P

PARANTHINE. H. Scapolite. K.

The primitive form of this mineral appears to be a strait prism with square bases.[*] The general figure, however, of its crystals, is an eight-sided prism terminated by planes or by tetrahedral pyramids. In some varieties the crystals are cylindrical, deeply striated longitudinally and laterally aggregated into bundles or plates. Sometimes also it occurs amorphous. Its colour is ash-grey, greenish, yellowish or brownish. When transparent, its lustre is vitreous, but by the progress of decomposition it becomes translucent, with a semi-metallic or pearly lustre. When perfect it scratches glass. Its longitudinal fracture is imperfectly conchoidal. Sp. gr. 3.6 — 3.7.

Before the blowpipe it melts with intumescence into a brilliant white enamel. The vitreous variety has been analyzed by Laugier, and the pearly by M. Simon, with the following results.

Vitreous	
45.	Silex
33.	Alumine
17.6	Lime
1.	Iron and Manganese
1.5	Soda
0.5	Potash
98.6	

Pearly	
53.	Silex
15.	Alumine
13.25	Lime
7.	Manganese
4.5	Oxyd of Manganese
2.	Oxyd of Iron
3.5	Soda
98.25	

It has hitherto been met with only near Arendahl in Norway, in the iron mines, mixed with mica, calcareous spar, and felspar.

PHOSGENE GAS. See MURIATIC ACID.

PHOSPHORUS. PHOSPHORIC ACID. PHOSPHATES, &c.

Messrs. Fourcroy and Vauquelin, in their analysis of Fish Roe (Ann. Chim. tom. 64) announced the discovery of phosphorus existing in this substance uncombined with any base, and obtained by simple distillation of the roe, which in its natural state could contain no free phosphoric acid nor phosphat of ammonia. The editor of this journal adds, that this dicovery of free phosphorus in organized bodies is entirely due to these chemists, as the only parallel case is the assertion of Margraaf, that he obtained phosphorus by the simple distillation of mustard seed, to which the editor is inclined to give little credit.

But M. Theodore de Saussure[a] has given some experiments which appear both to confirm the accuracy of Margraaf, as to the fact of obtaining phosphorus from seeds, and to throw doubts as to the real source of this phosphorus. He observes, that some years ago he had been strongly heating the black ashes of burnt beans, in a platina crucible, and he found part of the ash strongly agglutinated to the vessel, which was perforated and melted down in that place. A similar accident happening to Messrs. F. and V. in their analysis of fish-roe, they rightly attributed it to the action of phosphorus on the platina vessel, which caused M. T. de Saussure to undertake the distillation of wheat with care. Some wheat was first heated by itself for three hours moderately red-hot in an earthen retort, till no more vapours appeared. The coaly residue was then transferred to a small coated porcelain retort, fitted to a tubulated receiver, half full of water, and heated most intensely for three hours, in a fire strong enough to vitrify the lute entirely. A white fume smelling like phosphorus appeared at the end of the process, and the tube connecting the retort and receiver was found lined with a film of perfect phosphorus.

As the coal of wheat which furnished this phosphorus is sensibly alkaline, it is obvious that the phosphorus cannot proceed from any free phosphoric acid; neither is it likely that the previous calcination should have allowed any phosphat of ammonia to remain in the coal. There is only therefore the phophat of potash and phosphat of lime which could furnish the phosphorus; but as these salts have usually been thought undecomposable by charcoal, the author made the experiment.

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[a] Ann. Chim. tom. 65.

Thirty grammes of pure phosphat of potash, with a little excess of alkali, were mixed with twice as much beech charcoal, previously heated red-hot. The whole was intensely heated in a porcelain retort for four hours, and at the end about $2\frac{1}{2}$ grammes of phosphorus were collected, besides what was carried off in a gasseous form as phosphuretted hydrogen, and the oxyd of phosphorus which remained suspended in the water of the receiver. As the 30 grammes of phosphat of potash only contain by calculation 4.8 grammes of phosphorus, it cannot be doubted that phosphat of potash is decomposable by charcoal, and yields pure phosphorus.

Phosphat of soda treated in the same manner yielded the same proportion of phosphorus.

Phosphat of lime was prepared by adding phosphoric acid to nitrat of lime and separating the phosphat of lime by ammonia. Ten grammes of this phosphat previously made red-hot, were mixed with twice as much beech charcoal, previously washed to separate the small portion of alkaline and saline matter. This was heated in a porcelain retort as before, but the results were not so decided as in the last experiments, owing, as the author supposes, to the heat not being sufficiently intense. A similar mixture was therefore enclosed in a Hessian crucible, with a cover of platina, and the whole was imbedded in charcoal powder, in an outer earthen crucible and cover. This was heated two hours as intensely as possible. When cold, the platina cover was found melted, but the earthen crucible was sound. The contents that remained were digested in muriatic acid, and then precipitated, first by ammonia, which separated 4.52 grains of phosphat of lime, and then by carbonat of ammonia, which separated 5.22 grains of carbonat of lime. Hence it appears that about half the phosphat of lime had been decomposed in the process of ignition with charcoal. The phosphorus had of course been lost and consumed in the open fire, into which it had escaped.

The same experiment was repeated with the native Spanish phosphat of lime. Less of it was decomposed, but enough to render the experiment quite satisfactory.

It appears therefore, that it is a mistake to suppose that the phosphats of potash, soda, and lime, are undecomposable by heating with charcoal, and that former experiments have failed probably from not having the heat intense enough, or continuing it long enough.

It also appears as a direct inference from these experiments, that some traces of phosphorus, either in substance or as phosphuretted hydrogen, must be obtainable from all animal and vegetable matters by simple distillation, since they all contain phosphat of lime and charcoal: and hence that the appearance of phosphorus in these experiments is not of itself a sufficient mark of uncombined phosphorus in the substance distilled.

Phosphuretted Hydrogen.

It was mentioned under the article *Phosphorus (Chem. Dict. vol. 2)* that there appeared to be two distinct combinations of phosphorus and hydrogen, one is the well-known phosphuretted hydrogen, formed by heating phosphorus in a liquid solution of potash, and which is spontaneously inflammable when in contact with the air: the other is a gas which is a compound of phosphorus and hydrogen, but does not inflame spontaneously, and is probably the same as that produced by merely confining phosphorus in hydrogen. The properties of this gas, hitherto but little known, have been more fully investigated of late.

M. Theodore de Grotthuss, in a memoir on the metallic phosphurets notices a peculiar gas,[b] produced by boiling together liquid potash, phosphorus, and alcohol, which has the scent of phosphuretted hydrogen, but does not inflame spontaneously when mixed with oxygen, though the mixture detonates strongly when touched by any ignited body, and white phosphoric vapours concrete on the vessel. This gas detonates still more intensely and dangerously when mixed both with nitrous gas and oxygen, and ignited. With oxymuriatic gas it burns spontaneously and without explosion, with a beautiful green light. The products of the combustion are phosphoric acid, water, and carbonic acid. This compound gas therefore seems very distinct from the *sub-phosphuretted hydrogen* in question.

But this sub-phosphuret is more unequivocally noticed and its leading properties described, by Messrs. La Grange and Vogel, in a memoir on the action of phosphorus on alkalies.[c] The following is the experiment: melt some phosphorus in a phial full of hot water, cork it, and shake it violently till the water is cold, by which means the phosphorus will be simply divided into a fine powder. Dry this on blotting paper, mix it hastily with some dry caustic potash, just reduced to powder in a brass mortar cooled by ice, and put the mixture into a small luted earthen retort, with a tube of safety and a conducting tube to a mercurial trough. Heat the retort at first gently, and then gradually encreasing to whiteness. During the whole time a peculiar gas arises, which has the following properties: it is neither acid nor alkaline; it has a slightly alliaceous smell; it burns on the approach of a taper, but not spontaneously, either in oxygen or nitrous gas: when mixed with oxygen and ignited it detonates strongly: it is a little soluble in water, and the solution gives a black precipitate with nitrat of silver: it inflames rapidly with oxymuriatic gas, and then deposits some oxyd of phosphorus on the vessel. The residue of this distillation is a black shining mass resembling plumbago. It may be added, that where the only object is to procure the gas, and not to examine the action of phosphorus with accuracy, nothing more is required than to put a few small bits of phosphorus in a glass bottle, to cover them with very dry caustic potash, to adapt a tube going to a mercury bath, and to heat the bottle moderately, when the gas will be given out in abundance. If the alkali is wet, the gas will be the common spontaneously inflammable phosphuretted hydrogen, but by continuing the heat till the visible moisture is expelled, the above less inflammable gas succeeds. As later researches have shewn that even the fused dry caustic alkalies contain much water in their composition, there can be no difficulty in finding the source of the hydrogen on heating phosphorus and dry alkali.

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[b] Ann. Chim. tom. 64. Oct. 1807.

[c] Ib 66. for 1808.

This same sub-phosphuretted hydrogen (as it appears to be) has been also examined by Sir H. Davy with more accuracy, as to the proportions of its composition, and it has received from him the name of *Hydrophosphoric Gas*. It was obtained by heating in a close vessel solid *hydrat of phosphorous acid* (which will be presently described). Solid phosphoric acid is formed and a large quantity of this gas is given out apparently of great purity. This gas has all the properties of that just described, that is, in not being spontaneously inflammable, but exploding violently when mixed with oxygen, and exploding in oxymuriatic gas without the contact of an ignited body. Water absorbs one-eighth of its volume of this gas. The specific gravity of the gas is about 87 (common air being 100.) or 12 times that of pure hydrogen.

When potassium is heated in this gas, its volume is doubled, the phosphorus is extracted by the potassium, and pure hydrogen remains. Sulphur sublimed in it also doubles the volume, phosphuretted sulphur is produced, and the remaining gas is phosphuretted hydrogen. It appears to consist of 4.5 by weight of hydrogen, to 22.5 of phosphorus.

On the other hand, the common inflammable phosphuretted hydrogen has much less specific gravity, and never enlarges to more than 1.5 of its bulk of pure hydrogen when the phosphorus is extracted by potassium, and probably contains a double proportion of phosphorus.

Two distinct combinations of phosphorus and oxygen were described (*Ch. Dict. Art. Phosphoric Acid*) the *Phosphoreous* and *Phosphoric Acids*. Sir H. Davy gives the following estimation of their composition.[d] When phosphorus is heated in highly rarefied air three products are formed, one of them is *Phosphoric Acid*, which is fixed; another is a white powder, easily volatile, with a sour taste and garlic smell, and which burns when heated strongly, passing to the state of phosphoric acid. This volatile white powder is the *Phosphoreous Acid*, but mixed with a little phosphorus. The third substance is a red *Oxyd of Phosphorus*.

The phosphoreous acid is obtained in union with water by subliming phosphorus through corrosive sublimate, (in the way described under the article *Muriatic Acid* in this Appendix) and mixing the limpid compound of chlorine and phosphorus with water, and evaporating the solution to the consistence of syrup. Muriatic acid is given out, and the residue is a compound of phosphoreous acid and water, called by the author *Hydrophosphoreous Acid*. This as above mentioned, yields one of the species of phosphuretted hydrogen when heated.

Phosphoreous acid consists of about 20 of phosphorus and 15 of oxygen.

Phosphoric acid consists of 20 of phosphorus and 30 of oxygen.

The composition of the red oxyd is not well ascertained.

M. Thenard[e] finds that phosphorus always contains carbon, however often it is rectified, but when the carbon is in small quantity it does not impair the colour of the phosphorus.

Elements.

[e] Ann. Chim. tom. 21.

M. Thenard denies the existence of the supposed red oxyd of phosphorus, but considers it as a combination of phosphorus and carbon.

When the purest phosphorus is burned slowly in the air, some carbonic acid is obtained, owing to the combustion of the carbon which it contains. This amounts to 2 or 3 per cent. of the air employed, which, when phosphorus is employed eudiometrically, causes an error to this amount by making the absorption appear too little. This may be corrected by potash, which removes the carbonic acid. In the rapid combustion of phosphorus the carbonic acid is not produced.

PICROMEL. See Bile.

PINITE.

The primitive form of this mineral is a regular hexahedral prism, but it also occurs as a dodecahedral prism, and as a hexahedral prism with the lateral and terminal edges replaced by secondary facets. It is often quite opake, sometimes slightly translucent; its colour is blackish grey often superficially tinged by oxide of iron. Its cross fracture is imperfectly foliated, its longitudinal fracture is small-grained, uneven, with a glistening resinous lustre. It yields easily to the knife. Sp. gr. 2.98.

It is infusible *per se* before the blowpipe.

It was first found in the mine called Pini, at Schneeberg in Saxony, and has since been met with in France. It occurs in crystals single or crossing each other, and accompanied by quartz, felspar, and mica.

The Saxon variety has been analyzed by Klaproth, and the French by M. Drappier, with the following results.

63.75 —	42 -	Alumine
29.5 —	46 -	Silex
6.75 —	2.5	Oxide of iron
	7.	Volatile matter
100. —	97.5	

PLATINA.

§ 1. *Ores of.*

Since the publication of the Chemical Dictionary, platina, which at that time was considered as the peculiar product of Peru, has been ascertained to occur in the island of St. Domingo, in Brazil and in Spain.

The platina of St. Domingo[a] is met with in the eastern part of that island, in the sands of a river called Jaki, at the foot of the mountains of Sibao. It is in the form of flattened grains somewhat larger than the Peruvian, and is accompanied by magnetic iron ore, by gold, and probably by the other metallic substances which are mixed with the Peruvian ore: it has not as yet been analyzed.

The platina of Brazil[b] is found in the gold mines of that country in the form of small grains or fragments of a spungy texture, and entirely destitute of polish. It has been examined by Dr. Wollaston, and appears to be a natural alloy of this metal with gold and silver; and is mixed with grains of gold and of palladium alloyed with iridium, and probably with osmium and rhodium. It does not contain any of the magnetic iron sand or of the minute hyacinths which always accompany the Peruvian ore.

The Spanish platina was discovered by Vauquelin in an examination of the grey silver ore from the mines of Guadalcanal in Estremadura. This ore appears to contain copper, lead, antimony, iron, silver, sulphur, sometimes arsenic and platina, the proportion of which last varies from the smallest perceptible quantity to about 10 per cent. The gangue of this ore is generally calcareous spar, mixed with heavy spar and quartz.

The platina may be obtained from this ore by treating it alternately with nitric and muriatic acids, in which case the platina will remain undissolved together with the sulphur: or it may be procured by finely pulverizing and roasting the ore, then melting it with common potash into a metallic button, and afterwards submitting it to cupellation, being mixed on the cupel with the due proportion of lead, if the quantity naturally contained in the ore is not sufficient. The result of this process will be a button composed of silver and platina, from which the former is to be separated by quartation as described in the article Assay.

§ 2. *Analysis of Crude Platina.*

Nearly about the same time that Mr. Tennant and Dr. Wollaston were engaged in their examinations of crude platina (the interesting and important results of which have already been detailed in the Chemical Dictionary, article Platina,) M. Descotils and M. M. Vauquelin and Fourcroy were also occupied on the same subject. Their success indeed has not been so absolute and satisfactory as that of the English chemists, yet is well worthy of notice as tending, as far as it goes, to illustrate and confirm the other discoveries.

M. Descotils[c] began his operations by separating the heavier from the lighter grains of the crude platina, by means of a common bellows. The lighter part thus separated, consisted of siliceous grains of ferruginous sand attractable by the magnet, and of ferruginous sand not attractable. Of the two last the former proved to be menachanite, and the latter chromate of iron.

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[a] Ann. Chim. lxxiii. p. 334.

[b] Phil. Trans. 1809, p. 189.

[c] Ann. Chim. xlviii. p. 143.

The heavier grains were put into a porcelain retort, to which was adapted a balloon one third full of water, an intense heat was applied for two hours, and during the whole of the time light vapours were given off of a sulphureous odour, and in part soluble in the water of the receiver. At the end of the process the colour of the fluid was pale greenish, and in the course of a few days it had changed to a full ultramarine blue. The platina in the retort was agglutinated; and in the upper part of the mass the grains were brownish, as if they had been rusted; at the bottom the grains were scarcely coherent, and had retained their original metallic lustre.

The blue liquor in the receiver was first examined. With alkalies it yielded a blue deposit. By nitric and oxymuriatic acids the colour was first changed to lilac, and at length was entirely destroyed. Sulphuretted hydrogen gave no precipitate; but hydro-sulphuret of ammonia threw down a grey precipitate, which was changed by acids to blue. A blue sublimate had adhered to the beak of the retort; of this a part was fused with borax, and in consequence the blue matter assumed a metallic appearance, the borax remaining colourless: another portion being heated *per se* before the blowpipe was volatilized.

The platina remaining in the retort was next submitted to examination. For this purpose it was first digested with muriatic acid, in order to separate the greatest part of the iron, and then was exposed to the action of nitro-muriatic acid: during the action of this menstruum a black powder made its appearance, which if separated from the solution in proportion as it formed, amounted to about 3 per cent. but if left in the acid was for the most part dissolved.

The solution after it had become clear by subsidence was poured off, and concentrated solution of muriate of ammonia was added as long as any turbidness took place; the precipitate was yellow and was carefully washed till the washings were no longer coloured green by prussiate of potash. The residual liquor and washings were now mixed, concentrated by evaporation and again treated by muriate of ammonia which now threw down a deep red precipitate. The residual liquor was again evaporated and subjected to the same treatment as before, by which a second very red precipitate was obtained.

The black powder was next digested in nitro-muriatic acid, in which it was found to be partially and with difficulty soluble. The solution of a dark redish brown colour, afforded with muriate of ammonia, a precipitate apparently the same as the second red precipitate procured from the solution of the platina.

Equal quantities of the yellow salt obtained from the first precipitation and of the red salt obtained from the second precipitation were dissolved in equal portions of water. The colour of the former was bright golden yellow, that of the latter was redish-yellow with a tinge of green. Sulphureous acid or green sulphate of iron immediately, and alcohol after a time brought the latter solution to the same colour as the former. This circumstance induced M. D. to suppose that the deeper tinge of the one was owing to its being in a state of higher oxydation than the other. In consequence the yellow solution was treated with nitric acid, but without bringing it to the same degree of intensity of colour as was possessed by the red solution. Oxymuriatic acid was then tried, but the effect of this was to decompose the ammonia, and thus bring the salt to the state of simple muriate, from which a subsequent addition of muriated ammonia threw down a yellow salt.

Portions of the yellow and of the red precipitate were next slowly decomposed by heat, The metallic residue from the first dissolved totally and with remarkable facility in nitro-muriatic acid, and the solution on the addition of muriated ammonia deposited a precipitate perfectly similar to the original yellow salt. That from the last, on the other hand, required more acid, and after all there remained a portion of black powder absolutely insoluble by the acid: the solution afforded with muriated ammonia a red precipitate, the colour of which however was not so deep as that of the original precipitate. Another portion of the red precipitate was decomposed by heat; and the residue being placed within a porcelain tube, to one end of which was attached a retort with oxymuriate of potash, and to the other a balloon-receiver with water, was exposed to a strong heat, at the same time that a current of oxygen gas procured from the oxymuriate, was passed over its surface. After a time a blue sublimate passed into the receiver, and when this ceased the platina was taken out of the tube and exposed to the action of nitro-muriatic acid. It now dissolved in the acid without leaving any black residue, and the solution was somewhat less coloured than that of the original red precipitate.

If to a solution of the metallic base of the yellow precipitate in aqua regia be added any salt of soda, the result is a soda-muriate from which sal-ammoniac precipitates a salt perfectly similar to the original yellow precipitate. But if the red triple salt be converted in like manner into a soda-muriate, and the crystals hence resulting be exposed for some time to the action of the air they will acquire a greenish hue; being then dissolved in water, and oxy-muriate of lime being dropped in, a deep-blue precipitate falls down, which being heated with borax affords a spungy metallic mass, insoluble even in aqua regia. If the solution from which the green precipitate has been separated is now treated with sal-ammoniac, a yellow precipitate is produced perfectly similar to that formed in like circumstances from pure muriate of platina. From the above and other similar results M. Descotils concludes that the red salts of platina are coloured by a distinct metal in a particular state of oxydation; that this metal, by itself insoluble in acids, considerably impairs the solubility of the platina with which it is mixed; that in different states of oxydation it presents different colours, blue, violet, and red; that this new metal is in part at least volatilizable on exposure to heat with access of oxygen, in which case it assumes the form of the blue oxide.

The most important circumstances ascertained by M. M. Vauquelin and Fourcroy,[d] in their examination of crude platina are the following.

Having previously separated most of the menachanite and some of the chromate of iron, by the successive digestion of the ore in nitric, muriatic, and sulphuric acids, the residue was treated by repeated portions of nitro-muriatic acid till nothing remained undissolved except a black powder amounting to about 3 per cent. of the whole. Of this black powder 33 grammes (508.2 grains) were mixed with an equal weight of potash and exposed to a strong heat; the mass was then lixiviated with water as long as any thing soluble was taken up. The portion insoluble in alkali was digested in muriatic acid, and thus by alternating the menstrua nothing at length remained undissolved except a few metallic grains weighing about 3 grammes. It had been observed that during each lixiviation a very pungent odour not unlike that of horse-radish was given out; in consequence of this all the alkaline solutions were mixed together and submitted to distillation with proper precautions. The fluid that came over was obtained in three separate portions, of which the first had a highly pungent odour, but the last had very little. The corks by which the bottles holding these three liquors were closed had acquired a deep blue almost black colour, and a drop of the first product having fallen on the hand of the operator communicated to it an indelible deep-brown stain. To the taste these liquors were pungent and styptic.

A few drops of tincture of galls were added to part of the distilled liquor, which immediately produced a vivid blue tinge. Into another portion was dropped some prussiate of potash, but no precipitate took place; the liquor however became red, and on the addition of a little nitric acid passed to purple. Into another portion a little muriatic acid was dropped, and a stick of zinc was put into it, the fluid first became purple, then deep blue, and at length deposited a considerable quantity of a black flocculent matter insoluble in acids. A similar change of colour was occasioned by the addition of green sulphate of iron and of sulphuretted hydrogen.

The alkaline lixivium from which the above mentioned liquor had been distilled, was next examined, and was found to contain chromic acid combined with the potash.

The muriatic solution was the next object of enquiry. For this purpose all the muriatic solutions were mixed together and evaporated to dryness, in order to separate the silex which they had taken up in considerable quantity: the residue was washed with water which took up all the metallic salts. This latter solution being filtered and moderately evaporated (by which its colour had become a deep red) was mixed with a little muriatic acid, and exposed to the action of metallic zinc. In a short time the solution became first green, then blue, and finally deposited a copious flocculent matter of a brilliant black colour. This sediment was well washed in water, and afterwards in diluted muriatic acid in order to carry away any oxide of iron that might be present; it was lastly desiccated in a moderate heat and thus acquired a considerably brilliant metallic-white colour.

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[d] Ann. de Chim. xlix, p. 181-219. l. p. 5.

The metal when thus purified has nearly the appearance of platina, but is brittle and may be pulverized without difficulty. When strongly heated before the blowpipe it is volatilized entirely in the form of a white vapour. The only acid that has any action on this metal is the nitro-muriatic, and even this when assisted by a boiling heat will not take up nearly $\frac{1}{300}$ of its weight. The colour of the solution is nearly rose-red, which when almost dry changes to a very pure blue, and when perfectly desiccated returns again to its former colour.

If the metal finely pulverized be mixed with an equal weight of potash and calcined, the result is a greenish mass, which when digested in water affords a red solution, and a part not soluble in this fluid. The addition of any acid to the alkaline solution throws down the metal in the state of a flocculent red oxide. If strong muriatic acid be digested on the portion insoluble in water, it is for the most part taken up, communicating to the menstruum an intense green colour, which by dilution with water changes to blue, and by the subsequent addition of nitric acid to red. In no state does the solution afford a precipitate with prussiate of potash, provided it is entirely free from iron. Tincture of galls assisted by a little alkali changes the blue solution to a violet, and throws down a redish brown precipitate.

From these and other circumstances the authors of this enquiry draw nearly the same conclusions as Descotils does; namely that besides the known metals with which crude platina is mixed or alloyed, there is another as yet unnamed, to which the red colour of the triple salts of platina is owing, and which in all probability materially contributes to the hardness of all the specimens of this metal which have hitherto been offered to the public as pure platina.

§ 3. *Physical Properties.*

Dr. Wollaston in a paper recently laid by him before the Royal Society,[e] has pointed out a method of forming extremely thin wires of platina, which shows the remarkable ductility of this metal. He takes a globule of pure platina, hammers it into a square rod, and then draws it into a wire about $\frac{1}{250}$ of an inch in diameter. A portion of this wire is then coated in the usual manner with silver, forming a rod about $\frac{1}{3}$ of an inch in diameter; and this rod may again be drawn to the same degree of tenuity as the first platina wire. Hence the diameter of the platina in this compound wire is $\frac{1}{250 \times 75} = \frac{1}{18750}$ of an inch. In order to separate the platina from the investing silver the best way is to bend a portion of the wire into the shape of the letter U with small hooks at its upper extremities. In this form it will conveniently hang on a wire of gold or of platina with its lowest part immersed in nitrous acid, till the coating of silver is removed from that part. Platina wire of the above mentioned diameter will support about $1\frac{1}{3}$ grain before it breaks.

§ 4. *Chemical Properties.*

On this head we have only to add the composition of the oxides of platina as laid down by Berzelius.[f] If muriate of platina is gently heated on a sand-bath till it ceases to give out oxymuriatic gas, there remains a greenish grey powder insoluble either in water or in acids. This powder is however decomposeable by the fixed alkalies, which separate from it a black oxidulum that is itself soluble in an excess of alkali, forming a deep green liquor. In the oxidulum 100 parts of platina are combined with 8.28 parts of oxygen, and in the greenish-grey oxide with twice as much, or according to actual experiment, with 16.38 parts of oxygen.

It appears probable however from the insolubility of the platina, from the black deposit after the action of the alkali, and from the green colour of the alkaline solution, that the platina employed by M. Berzelius was contaminated by a mixture of iridium.

PLEONASTE, H. Ceylanite, W.

The colours of this mineral are blue and green, each so intense as to appear almost black. It occurs in rolled grains or in small crystals; which are either the regular octohedron (its primitive form) or the rhomboidal dodecahedron, perfect, or with the trihedral solid angles replaced by four facets. It rarely exhibits indications of the natural joints, the fracture being perfectly smooth and flat conchoidal, with a shining somewhat resinous lustre. It scratches quartz, but is inferior in hardness to the red spinelle. Sp. gr. 3.7.

Before the blowpipe it is infusible. The only analysis that has been made of it is by M. Collet Descotils, according to whom it is composed of

68.	Alumine
12.	Magnesia
2.	Silex
16.	Oxyd of iron
98.	

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[e] Phil. Trans. 1813, p. 114.

[f] Ann. de Chim. lxxxiii. p. 168.

It occurs in the sand of Ceylon, and has more recently been found among the substances ejected from Vesuvius.

This substance is at present ranked by Haüy as a variety of Spinelle, with which it agrees in its crystalline form, and differs but little in other particulars.

POTASH, *Pure, and Hydrat of.* See Alkali Fixed.

POTASSIUM. See Alkaline Basis.

PRUSSIC ACIDS. Prussiats.

Some additions have been made to our knowledge of this very singular class of substances, though the subject is still peculiarly difficult. What we have at present to offer relates to actual experiments and matters of fact.

Prussiat of Potash. The simple combinations of prussic acid with the salifiable bases were shewn by their eminent discoverer, Scheele, to be peculiarly easy of decomposition, the prussic acid being volatilized and expelled from its bases by every other acid, and even by a boiling heat when in solution. Several chemists however have attempted to prepare a simple prussiat of potash directly from the lixivium of blood, without the intervention of any salt of iron, and the following is the process of Richter.[a]

Evaporate to dryness a strong solution of a pound of pure salt of tartar, or subcarbonat of potash, with 3 pounds of dried and pulverized ox-blood. When quite dry, put the whole in a covered crucible and heat it in a moderate fire till it no longer puffs up: then raise the heat to redness, and continue it till no more flame issues from the crucible. Remove the contents and lixiviate them with water. This liquor is quite limpid, alkaline, and gives ammoniacal fumes. Evaporate it considerably (during which it gives out an intense bitter-almond smell, which always attends the volatilization of free prussic acid) and then add acetite of lime as long as there is any precipitate of lime produced by the excess of alkali, after which filter the liquid and boil it down till it skins over, and then set it by in a cool place. In about twelve hours many small crystals are deposited of the shape of a cube truncated horizontally, and more of the same crystals are yielded by a further concentration of the mother liquor. Collect them all, and purify them by again dissolving them in water, evaporating, and crystallizing as before, but this is attended with some waste of the prussic acid, as the same bitter-almond smell is given out, and the liquor becomes slightly alkaline. Therefore to avoid further loss, again purify this second crop of crystals by drying them on blotting paper, washing them with some alcohol mixed with an eighth of acetic acid, and again drying them on paper.

By this process about an ounce and a half of the crystallized simple prussiat of potash is obtained. This salt has a caustic taste mixed with the same flavour of bitter almonds, and the odour of the same is perceived when the salt is dissolved in water and heated; but not when it is heated by itself. When this salt is boiled with prussian blue, a yellow solution is formed, which yields the common triple prussiat of potash and iron.

To this process of Richter the following observations are added by Bucholz.[b] The best proportions of the material are two parts of dried blood to one of alkali. No advantage whatever is gained by using a perfectly caustic alkali. The prussic acid is not very easily destroyed by dry heat, for much of it remains in the alkali even when it begins to fuse: but the process of evaporation should be shortened as much as possible, as the prussic acid is constantly flying off during the whole time. There is always much uncertainty in this mode of obtaining the prussic acid and a good deal of waste in every step of the operation, and even the treatment with alcohol and acetous acid, recommended at the end, does not merely saturate the excess of carbonat of potash, which is the object of this addition, but liberates much prussic acid which is thus lost.

Proust has the following observations on the simple prussiat of potash. It may be obtained either by saturating potash with the prussic acid expelled in the usual way from prussiat of mercury, or by digesting alcohol with a concentrated lixivium of potash and calcined blood prepared as above described. The alcohol gradually gains a bitter alkaline taste as it dissolves the prussiat. Generally a little hydrosulphuret of potash is contained in the lixivium, which is also dissolved by the alcohol. The prussiat of potash is then obtained in a solid state by evaporation and crystallization.

When the watery solution of this simple prussiat is boiled, it constantly parts with its acid as already mentioned, and the vapour burns when a lighted taper is brought to it. Besides which, another part of the prussic acid is decomposed in the boiling lixivium itself, producing carbonat of ammonia, which appears in a gradually encreasing quantity as the boiling is continued. During the whole time the potash as it loses prussic acid acquires carbonic acid, so that the lixivium, which at first does not alter muriat of lime, gives an abundant precipitate of carbonat of lime after continued boiling.

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[a] An. Chem. tom. 51. p. 182.
[b] Ibid. page 185.
[c] Ibid. tom. 60.

All that has been observed concerning the prussic acid shews the extreme facility with which it separates from its simple union with an alkali, as Scheele has remarked.

To proceed with Proust's observations:

Triple Prussiat of Potash and Iron, or Common Crystallized Prussiat of Potash—Prussian Blue—White Prussiat of Potash and Iron.

The triple prussiat of potash and iron does not change on exposure to air, nor does it (like the simple prussiat) lose any acid by long boiling. It is also insoluble in alcohol. The iron which it contains is the *suboxyd*, and it is to this that it owes its property of producing Prussian blue with the *peroxyd* of iron. We are not acquainted with that prussiat of iron in a separate form which constitutes all but the alkaline portion of this triple prussiat, for though this salt is produced by Prussian blue and alkali, the Prussian blue is partly decomposed in the process, and parts with a portion of *peroxyd* of iron, which, dissoving in another portion of the alkali, forms an alkaline solution of iron at the same time.

The hydrosulphurets of potash and ammonia have no action on the triple prussiat of potash and iron, even when boiled with it.

The author gives the following improved method of producing the *White Prussiat of Iron.* Put into a phial a very dilute solution of green sulphat of iron, and keep some bits of sulphuret of iron at the bottom to preserve the low degree of oxygenation. Boil in a matrass 15 or 20 grains of crystals of triple prussiat of potash in 3 ounces of hydrosulphuretted water. When the vapour of the boiling liquid has issued for several seconds, and expelled most of the common air in the matrass, add the solution of sulphat of iron by drops, and the liquid will immediately become as white as milk, and continues so as long as the boiling is kept up. On standing a few seconds a precipitate falls to the bottom, which is the white prussiat; but then the effect of the atmosphere begins, and a blue tint forms on the surface, which gradually extends downwards through the whole mass.

Prussian Blue. It is an opinion, we believe, peculiar to Proust, that the prussic acid in this compound is united not to the *peroxyd* but to the *suboxyd*, or black oxyd of iron. This substance does indeed contain a certain quantity of the peroxyd, as is proved by the conversion of the white into the blue prussiat by absorption of oxygen, but the author asserts that the same portion of suboxyd remains united to the prussic acid, as was before combined with it in the triple prussiat from which the blue prussiat is produced. Hence when Prussian blue is produced by adding the triple prussiat of potash and suboxyd of iron to any other salt of iron, it is the oxyd of the latter salt only that passes to the highest state of oxydation (if it were not so before) and the suboxyd of the triple prussiat accompanies it unchanged.

The chief reason which the author gives for this opinion of the unchangeable nature of the suboxyd whilst united with prussic acid in Prussian blue, is, that if the *peroxyd* of iron is digested with prussic acid, no combination whatever will take place, but if the *suboxyd* be used a green prussiat will be formed, which soon becomes blue by contact of the air. This last fact would indeed lead to the conclusion that the blue colour is an indication of perfect oxygenation of all the iron present, since it is produced obviously by absorption of oxygen from the air: nor is it easy to explain this experiment on Proust's hypothesis, of a mixture of suboxyd and peroxyd in Prussian blue.

It is a fact however, and was early noticed by Scheele, that the simple prussic acid, or the simple prussiat of potash, will not give any precipitate with any salts of iron, except those in which the metal is in the lowest state of oxydation; but the precipitate once being formed, a portion at least of the suboxyd passes to the state of peroxyd by absorption of oxygen, and gives the deep tint of Prussian blue.

Prussic Gas.[d] The pure gasseous prussic acid is obtained by heating in a retort triple prussiat of potash with dilute sulphuric acid. The gas may be received either in water or alcohol, or over mercury, and when either of these liquids is introduced, it will absorb the gas rapidly. The prussic gas is constantly tending to escape from the watery solution, and when the liquor is warmed so that the gas is given out rapidly, it will burn in an uniform jet of flame, when lit by a taper. The watery solution will also decompose by itself, even when kept in a closed vessel. It turns yellow in a few months and deposits a sediment of charcoal. The watery

[d] An. Chim. tom. 77.

solution of prussic gas if recent, does not trouble even the solution of green sulphat of iron, but if it has been long kept, the blue precipitate is formed, which is a triple compound of the prussic acid, of suboxyd of iron, and of the ammonia generated by the spontaneous decomposition of part of the prussic solution.

On the other hand alcohol saturated with prussic acid preserves it without change.

M. Gay Lussac has given some further particulars respecting the prussic acid, in which he shews that when free from any combination, the gas may be condensed into a peculiar liquid. Some prussic gas was prepared by decomposing prussiat of mercury with muriatic acid, and was collected over mercury. During the operation some globules of liquid came into the vessels holding the gas, and on the following day, when the temperature had fallen to 54°. Fahr. the volume of prussic gas had much lessened, and more of this liquid had condensed. Another mode of preparing it was then employed: some prussiat of mercury was put in a tubulated retort, in the beak of which a bent tube was luted, the other end of which dipped into a tubulated bottle, holding a mixture of dry muriat of lime and chalk, intended to detain both the water and the muriatic acid that might come over. A tube proceeding from this bottle led to a second similar bottle containing muriat of lime, and this was joined to a ground stopper glass phial, in which it was proposed to collect the pure prussic acid. This and the two other tubulated bottles were surrounded with ice and salt. Muriatic acid was then poured into the retort, and gently heated. The prussiated mercury soon dissolved, vapours condensed in streaks on the neck of the retort, and the operation was stopped as soon as water began to be vaporized.

All the prussic acid thus obtained, usually condenses in the first bottle adhering to the muriat of lime, which last remains dry if no water has distilled over, but if any has passed, the bottle contains two unmixed liquids, of which the lower is a solution of muriat of lime in water, and the upper is the prussic acid. To rectify it, it is only necessary to remove the retort, to close the orifice where the tube from it entered the first bottle, to remove the freezing mixture from this alone, and instead, to heat it very gently not exceeding 85° or 95° Fahr. By this means the prussic acid is driven into the second bottle; and by a further rectification it may be made to pass into the third. Indeed the second bottle with muriat of lime appears superfluous, and may probably be omitted.

Prussic acid thus obtained is a limpid colourless fluid. Its taste is at the first moment cool, but soon becomes hot and acrid. Though rectified from chalk it weakly reddens litmus paper. Its density at 45° is 0.7058. It is highly volatile, and boils at 79°.: at 68°. it supports a column of mercury at 14.96 inches (Eng.) it encreases five-fold the bulk of any gas with which it is mixed. When exposed to the cold produced by a mixture of salt and snow it congeals, often into regular crystals resembling fibrous nitrated ammonia. It begins to liquify at 5°. When a drop of it is put upon paper it congeals instantly, owing to the cold produced by the evaporation of one portion reducing the temperature of the remainder.

We shall add (from Proust) a few additional observations concerning the simple prussiat of mercury. The basis of this salt is the *red oxyd* or *peroxyd* of this metal, and it differs from most of the other simple prussiats by being much more fixed, and not parting with its acid by mere solution and boiling. When prepared from prussian blue containing potash, it will carry with it part of the potash, and also some oxyd of iron. The latter may be separated by repeatedly boiling the prussiat with red oxyd of mercury, during which it deposits the red oxyd of iron which it held in solution. Prussiat of mercury readily crystallizes in tetrahedral prisms. It is totally decomposed by gradual distillation, giving a highly inflammable prussic gas mixed with oil and carbonic oxyd and acid, and about 72 per cent. of mercury. There appears to be no prussiated *suboxyd* of mercury, for when prussic acid is digested with calomel or with the nitrated suboxyd of mercury, running mercury and the common prussiat of mercury are obtained. Both the simple and the triple prussiat of potash are decomposed by red oxyd of mercury; in the latter case long boiling is required, the iron of the triple prussiat is deposited as peroxyd, and along with it some running mercury which has probably been brought to the metallic state by yielding oxygen to the iron, and the rest of the mercury unites as red oxyd to the prussic acid. Muriatic acid heated with prussiat of mercury totally decomposes it, the prussic acid is given out, and the residue is totally soluble in alcohol (which prussiat of mercury is not) and is merely corrosive sublimate.

PYCNITE. See TOPAZ.

PYROACETIC SPIRIT. See ACETIC ACID.

PYROPHYSALITE. See TOPAZ.

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SARCOLITE. See ANALCIME.

SCHILLERSPAR. See DIALLAGE.

SILEX. SILICIUM.

The existence of a pure metallic basis, of which silex is an oxyd, has been made probable by several experiments, first by the eminent discoverer of the alkaline bases, and afterwards by Berzelius and Stromeyer.

When iron is negatively electrified,[a] and fused by the Voltaic battery in contact with silex, the metallic globule contains a matter which affords silex during its solution. As the globule has an uniform metallic appearance, it may fairly be presumed to be an alloy of iron with some other metallic substance, which in all probability is the *basis of silex*, since silex is produced on solution of this alloy. Also when potassium is ignited in contact with silex, a compound is formed consisting of potash, in which are black particles resembling plumbago, which are supposed with probability to be the same metallic basis of silex. They are but little acted on by water, but they slowly dissolve in acids with effervescence, and when heated they burn and become converted into a white matter which is silex. This metallic basis of silex is termed *Silicium*.

Professor Berzelius has obtained this substance in combination with iron in the following way.[b] A mixture of 3 grammes of iron filings, 1½ gramme of silex, and 0.66 of a gramme of powdered charcoal were exposed for an hour to a blast furnace in a luted crucible. In the mass when cold were found small metallic reguli, which were extracted by the magnet, and cleaned on paper. Some of them were put into dilute sulphuric acid, and slowly dissolved therein when heat was applied. When all action of the acid had ceased, the forms of the globules still remained, but of various colour, and all of them when burned in open fire left a red or a white ball of silex of the same shape as the original globule. The silex amounted to about 3½ per cent. of the weight of the globule.

Another similar experiment was made, but with less charcoal. Equal parts of ground flint and iron filings and $\frac{1}{25}$ of their weight of powder of charcoal were made into a paste with gum, and divided into little balls. These were packed up in powder of flints, enclosed in a luted crucible and heated as before. The globules thus obtained were less perfectly fused than the former, but more malleable. When digested in aqua regia, the iron was dissolved with vehement action, and the acid left a white mass of silex of the form of the globules, which swelled by continued digestion with the acid, and became semi-gelatinized on evaporation. The silex in this experiment amounted to about 19 per cent. of the whole globule.

The author relates many attempts made to analyze these globules with accuracy, in order to ascertain the proportion of *Silicium* in them (supposing them to be a triple alloy of iron, silicium, and carbon) and hence, by the difference of weight between the silicium and silex, to infer the quantity of oxygen absorbed by the latter. This analysis could not be brought to a very satisfactory degree of accuracy, chiefly on account of the difficulty of finding the exact quantity of carbon, owing to a conversion of part of it into a kind of fetid oil during the action of acids, but the average results of the experiments would give the composition of silex to be about equal weights of silicium and oxygen.

A later series of interesting experiments on the same subject has been made M. Fred. Stromeyer, who has gone over the same ground as Berzelius, and with nearly similar results.[c] Great care was taken to select very pure iron, silex, and charcoal, the latter was pure lamp-black, to avoid the small proportion of potash which all wood charcoal gives when burnt. The whole was made into a paste with linseed oil, and heated most intensely for an hour in a luted hessian crucible. As to the respective proportions of these three ingredients, the author found from many trials most uniform success from 5 parts of silex, 7 of iron, and from 0.25 to 0.8 of lamp-black. With from 0.25 to 0.5 of the lamp-black the alloy remained more or less ductile, but where it exceeded 0.5 it was brittle. Much difference however was found between the globules of alloy resulting from the very same operation, in their size, colour, lustre, ductility, and also in their composition, so that the effect of the fusion is very unequal in the different parts of the same crucible.

The specific gravity of these globules of alloy varied from 6.77 to 7.32, and was always much inferior to that of the iron used, which was 7.828. The author describes several varieties in the texture and other sensible properties of these globules. One of these bears a very strong resemblance to common steel, and like steel it becomes hardened by being quenched in water when red-hot, and it also assumes the usual shades of colour on being heated to different degrees. All the varieties of this alloy are harder than forged iron, and take a very high polish, and also are perfectly magnetic.

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[a] Davy's Elements.

[b] Phil. Mag. No 173. From the original Swedish.

[c] Ann. Chim. tom. 81. From the Gottingen Transact.

M. Stromeyer gives the particulars of the analysis of every variety of these globules of alloy, which is rendered difficult for the reason already mentioned, namely the uncertainty in estimating accurately the carbon. Nevertheless he finds full reason to infer the probability of the existence of *Silicium* for the following reasons, viz.

That the iron and silex extracted from the alloy (estimating the iron in the reguline state) when taken together very sensibly exceed the weight of the alloy examined, even making no allowance for the carbon: that the alloy gives a much greater quantity of hydrogen with muriatic acid than the iron alone which it contains would give: that there is no known mechanical or chemical combination of a metal with an earth, which requires the successive operation of the most powerful reagents to decompose as this alloy does; and that the iron retains its malleability in this alloy, this property being apparently only affected by the proportion of charcoal present. For all these reasons therefore it appears hardly to be doubted that it is the metallic basis of silex, and not the earth itself which enters into this triple alloy.

The general mean results of these experiments give the composition of silex to be 46 per cent. of silicium, and 54. of oxygen.

In the different varieties of the above-mentioned alloy, the component parts of the most brittle, which is termed the *lamello-granulated silicio-carburetted iron*, are 85.352 of iron, 9.268 of silicium, and 5.38 of carbon: and the most ductile contains 96.178 of iron, 2.212 of silicium, and 1.61 of carbon: the silicium therefore varies from about 2.2 to 9.2 per cent. The alloy is sub-ductile when the silicium does not exceed 3 per cent.

SILVER.

For some further observations on the composition of the oxyd and muriat of silver, see the article *Affinity* in this appendix.

SODA, pure, and hydrat of. See ALKALI FIXED.

SODALITE.[*]

This mineral occurs massive and crystallized in rhomboidal dodecahedrons. Its colour is bluish green. It exhibits joints in at least two directions. Its longitudinal fracture is foliated with a shining resinous lustre; its cross fracture is conchoidal with a vitreous lustre. It is translucent, yields with difficulty to the knife. Sp. gr. about 2.37. When heated to redness it acquires a dark grey colour; it is not fusible *per se* before the blowpipe.

It has been analyzed by Dr. Thomson and M. Ekeberg, with the following results.

T.		E.	
38.52	—	36.	Silex
27.48	—	32.	Alumine
23.5	—	25.	Soda
3.	—	6.75	Muriatic acid
1.	—	0.25	Oxyd of iron
2.70	—	——	Lime
2.1	—	——	Volatile matter
98.3		100.0	
1.7 Loss			

It occurs in Greenland associated with sahlite, augite, hornblende, and garnet.

SODIUM. See ALKALINE BASIS.

SPINELLE *Zinciferous*. See AUTOMALITE.

SPINELLANE.

This mineral occurs in minute rhomboidal crystals of a blackish-brown colour. It scratches glass, and when exposed to the blowpipe becomes first white and then fuses without difficulty into a white very frothy enamel. It has been found by M. Nose on the border of the lake of Laach, in a rock composed of grains and small crystals of glassy felspar, of quartz, hornblende, black mica, and magnetic iron ore.

STILBITE.

It occurs crystallized or fasciculated. Its form is a four or six-sided prism, truncated, or with pyramidal terminations, the faces of which are unequally inclined with regard to each other. It is transparent, translucent, and sometimes almost opake. Its colour is white, grey, or brown, with a pearly lustre. It exhibits natural joints only in one direction: its cross fracture is uneven, glimmering. It scratches calcareous spar, but is softer than glass. Sp. gr. 2.5.

It is not electric by heat; by digestion in cold nitric acid it swells, but does not gelatinize. On exposure to the blowpipe it first exfoliates, and then melts with ebullition and phosphorescence into a white enamel.

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[*] Thomson in Phil. Journ. xxix. p. 288.

According to an analysis of this mineral by Vauquelin, it is composed of

52.	Silex
17.5	Alumine
9.	Lime
18.5	Water
97.0	
3.0	Loss

It occurs sometimes in mineral veins, but generally filling cavities in amygdaloid.

STONE METEORIC. See AEROLITE.

SUGAR.

A singular mode of converting starch and other insipid vegetable matter into a highly saccharine matter has been discovered by M. Kirchoff of St. Petersburg, and amply confirmed by subsequent trials.

It consists simply in boiling a solution of the starch for many hours with a small quantity of sulphuric acid, during which the mixture will gradually acquire a sweetish taste, and this saccharine quality encreases to a certain point, after which the acid (which does not appear to be decomposed in the process) must be saturated with lime, and separated in the form of sulphat of lime, and the remaining liquid which is then a rich syrupy mass, may either be evaporated to dryness, or (by way of experiment) may be mixed with yeast and fermented, and will then yield a considerable quantity of ardent spirit by distillation. It does not appear however that a very pure crystallized sugar has ever been obtained in this way, though the saccharine mass has both the taste and the most important chemical properties of sugar.

M. Kirchoff's original experiment is the following.[a] Take 100 lbs. of starch, 400 lbs. of water, 1 lb. of sulphuric acid, and some powdered charcoal and chalk. Mix the acid with half the water, bring it to boil in a well tinned copper; rub the starch with the rest of the water, pass it through a sieve, and add it by six ounces at a time to the boiling acid and water. Then continue the boiling for 36 hours, adding fresh water to supply the waste by boiling. Afterwards add a little charcoal powder and chalk sufficient to saturate the acid, and pass through a linen cloth the liquid which is now clear and sweet. Evaporate it by a gentle heat to the consistence of syrup, and set it by, that the sulphat of lime may crystallize. Remove this, strain the liquid part and again set it by, when the rough sugar will separate in about three days. This may be pressed with ease from the adhering syrup, and by being again dissolved and crystallized, will become much purer.

If a greater quantity of sulphuric acid is employed, the boiling must be continued longer.

Not only the sulphuric, but the muriatic and some of the other acids will thus convert starch into sugar, but the sulphuric is by much the most convenient, as when it has performed its office, it may be removed with great ease by means of lime.

M. Kirchoff's experiment has been repeated much at large by M. Vogel.[b] Some starch was first washed with cold water merely to purify it; then 2000. parts of it rubbed with 8000 parts of water acidulated with 40. parts of sulphuric acid, were boiled for 36 hours in a silver vessel (which is much better than one of copper or tin) with stirring, at first constant, afterwards only occasionally. The process was conducted as above described, and a quantity of rich syrup about equal to the starch employed was obtained. M. Vogel also got an equal quantity from twice the proportion of acid, and only eight hours boiling. This syrup boiled down slowly in tin moulds gave a solid transparent elastic mass, which attracted moisture from the air. A portion of it mixed with yeast and fermented, yielded alcohol by distillation.

A similar saccharine gummy mass was obtained from potatoe starch. This was further analyzed by boiling alcohol, which left undissolved about a fifth of the whole in the form of a viscous matter much resembling gum arabic when dry, but differing from it in not forming the mucous acid when treated with the nitric.

M. Vogel then tried the effect of a similar boiling with sulphuric acid upon sugar of milk, which though saccharine to the taste is not capable of the vinous fermentation: 100 parts of sugar of milk, 2 parts of strong sulphuric acid, and 400 parts of water were boiled together only for three hours, and the excess of acid neutralized by chalk. On evaporating the clear syrup it concreted in a few days into a rich saccharine mass, which *now* would ferment on adding yeast, and yielded alcohol by distillation.

Muriatic acid was found to have the same effect as the sulphuric upon sugar of milk, but not the nitric or acetic acids.

We shall relate another experiment on the same subject, performed by Dr. Tuthill, as it appears to have been made with great attention.[c] One pound and a half of potatoe starch, six pints of distilled water, and a quarter of an ounce, by weight, of sulphuric acid were boiled together in an earthen vessel for thirty-four hours without intermission, the waste by evaporation being supplied by fresh water, and frequent stirring being used to prevent the material from burning. The liquid had become sensibly sweet to the taste at the end of twenty four hours, and this sweetness encreased as long as the boiling was continued. At the end of this time, half an ounce of finely powdered charcoal was added, and the boiling continued two hours longer. The acid was then saturated by lime, the boiling continued half an hour longer, the liquid strained through cloth, and the residue rinced in warm water. This latter, when dry, weighed $\frac{7}{8}$ of an ounce, and consisted chiefly of charcoal and sulphat of lime. The filtered liquid was then evaporated in a water-bath to the consistence of syrup, and set aside. In eight days it had concreted to a crystalline mass, tasting like a mixture of brown sugar and treacle. One pound of this sugary matter was then dissolved in four pounds of water, a quarter of an ounce of yeast was added, the mixture was fermented, distilled and rectified, and gave a weak ardent spirit, which from Blagden's tables was found to contain 14 drams by measure of proof spirit. The whole amount of the saccharine matter was $1\frac{1}{4}$ lb., the produce of $1\frac{1}{2}$ lb. of starch from $8\frac{3}{4}$ lbs. of potatoes.

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[a] Journ. de Physique for March 1812, or Retrospect, No. 33.

[b] Ann. Chim. tom. 82.

[c] Phil. Journ. vol. 33.

Such are the facts of this singular process. The explanation of it is very obscure. It might at first be supposed that the sulphuric acid was decomposed by the vegetable matter, but from the experiments both of Vogel and Bouillon La Grange,[d] it appears that this is not the case. Not only is no sulphureous acid generated, but no sign of acidity whatever is given by the liquid condensed from the vapour of these materials when boiling, (which is mere water) and besides it appears that the acid remaining in the syrup after the long boiling, will saturate as much of any base as it would have done before mixture with the starch.

Some chemists have suggested that the mere effect of heat on the starch might convert it into sugar independently of the acid, but on trial, by boiling starch and water together for four successive days a liquid mass was obtained, not in the smallest degree saccharine, but only a bitter mucilage.

La Grange made the experiment of boiling 100 grammes of sugar of milk, 4 grammes of sulphuric acid, and 400 grammes of water, in a retort, and collecting all the products. No gas whatever was given out but the air of the vessel. A given quantity of potash was then added to saturate the acid, and the whole was evaporated to dryness. It was then weighed, and amounted only to 98 grammes. This experiment was repeated several times with a very close resemblance in the results, the loss of weight being at times a little more or less, but always much more than the water originally added, and that which might exist in the sulphuric acid.

The inference which the author makes is, that as no gasseous product was given out, and as no liquid but water distilled over, this loss of weight can only be accounted for from the production of a quantity of water from the sugar of milk employed. A similar result took place with starch. Hence it would appear not improbable that when starch, sugar of milk, &c. lose a certain quantity of hydrogen and oxygen (in the same proportions in which these constitute water) they approach to the nature of sugar. Some light may be thrown upon this subject by the *Analysis of Vegetable Matter (given in this appendix)* conducted by Gay Lussac and Thenard, by which these eminent chemists appear to have proved that all these vegetable matters, namely starch, sugar, sugar of milk, mucilage, &c. consist merely of carbon and water, or its two materials in their proper proportions, and hence the sole abstraction or addition of water assisted by some powerful chemical reagent, may convert one into the other.

SULPHUR, Alcohol of. Liquid Carburetted Sulphur.

In 1796, M. Lampadius distilling martial pyrites with charcoal, obtained a very singular liquor, to which he gave the name of *Alcohol of Sulphur*, and considered it as a compound of sulphur and hydrogen.

Messrs. Clement and Desormes, some years after, obtained the same liquid by passing the vapour of sulphur over well dried charcoal ignited in a porcelain tube, and from the result of many experiments, they considered this fluid as a compound of two thirds sulphur, and one third charcoal, whence they termed it *Carburetted Sulphur*, and denied the existence of hydrogen as a constituent part.

Afterwards M. Amedeé Berthollet, in a very elaborate and skilful series of experiments on this fluid, was led to conclude that it contained no charcoal whatever, but was produced by the union of sulphur and hydrogen in variable proportions.

Some experiments made by M. Vauquelin on the same substance have led this eminent chemist to a similar conclusion with that of Messrs. Clement and Desormes. Lastly, M. Cluzel in a very elaborate memoir, read at the Institute in December 1811, has considered this liquor as a quadruple compound of charcoal, hydrogen, azote, and about half its weight of the *Radical of Sulphur*, considering sulphur itself as a protoxyd of this unknown radical.

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[d] Ann. Chim. tom. 82.

We shall give a short account of the experimental part only of these different enquiries.

The different processes for obtaining the alcohol of sulphur are the following.

Lampadius procured it accidentally by distilling together pyritous peat, and pyrites with charcoal.

Clement and Desormes give the following process.[a]

This substance is obtained by passing sulphur through a porcelain tube heated to redness, which is filled with charcoal, partly in powder, and partly in lumps, and previously heated. The charcoal should be heaped pretty close.

The apparatus used, was the porcelain tube holding the charcoal and placed a little slanting across the furnace. To the upper end of the porcelain tube, a long and wide glass tube is cemented, holding a series of small cylinders of sulphur, which can be successively pushed forwards into the other tube by an iron pin which passes through the cork that shuts the upper end of the glass tube. To the lower end of the porcelain tube is fitted a glass adopter terminated by a bent tube, dipping in a tubulated bottle of water, which also communicates with the pneumatic trough.

The charcoal should be first strongly ignited till all the gas which it spontaneously yields is given off, then the bits of sulphur should be gradually pushed down, and by their action upon the heated charcoal, a yellowish oily limpid fluid condenses in the adopter. As the process continues, and the adopter becomes heated, the fluid is partly volatilized, but is again caught in the further bottle at the bottom of the water, where it collects in globules. Some care is required not to push on the sulphur too hastily, otherwise much of it passes through unchanged, and is apt to block up, and sometimes to break the tube of the glass adopter. No gas whatever escapes whilst the alcohol of sulphur is forming, except the expanded air of the apparatus. The alcohol of sulphur may be obtained, though with difficulty, by heating together charcoal and sulphuret of antimony.

The directions given by Vauquelin[b] for the preparation of the liquid, differ but little from the former. The bottle that receives the fluid should be connected with another bottle, and surrounded with snow or bits of ice to keep the water quite cool, as the alcohol of sulphur is very volatile. It is of use also to cut a notch at the bottom of the tube that dips in the water of the first bottle, to serve as a tube of safety to prevent the hot porcelain tube from cracking by any regurgitation of water into it. By using two bottles, and keeping the furthest at a freezing temperature, all the alcohol of sulphur is condensed. In the operation the porcelain tube should be kept white hot, and the sulphur added very gradually. If too much of it passes at once, a portion of it unites with the condensed alcohol of sulphur, giving it more colour and density, and rendering it partially concrescible when it touches the water. As soon as the sulphur begins to act on the charcoal, a large quantity of sulphuretted hydrogen is disengaged, but this ceases almost entirely as soon as the alcohol of sulphur condenses.

M. Amedeé Berthollet[c] prepares the alcohol of sulphur nearly in the same way as that last mentioned. The tube in which the mixture is made is of glass, and about 40 inches long; it is laid a little inclined across a furnace, the lower end projecting from the sides of the furnace only about 4 inches, and the upper end about 20 inches. The part inclosed within the furnace is covered with a very refractory fire-lute. The upper end is filled with flowers of sulphur, and then sealed hermetically. The middle is filled with charcoal; and the lower end is cemented to an adopter fitting into a small tubulated receiver, which communicates by a tube with a double tubulated bottle half filled with water, one tube of which conveys the gas after passing through the water of the bottle into the pneumatic trough. The charcoal in the tube is then intensely heated, after which the sulphur is melted gradually so as to flow down into the charcoal.

As soon as the sulphur and charcoal are in contact with each other, a copious disengagement of gas takes place, and at the same time the adopter becomes filled with white vapours, which condense into the yellowish limpid liquid, which is the alcohol of sulphur. When the object of the experiment is only to form this alcohol, the charcoal should be kept only at a cherry-red, and the influx of sulphur should be very slow. The production of the alcohol of sulphur ceases spontaneously after a time, unless the heat is raised very intensely, when the flow of the liquid is renewed.

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[a] Ann. Chim. tom. 42. p. 136.

[b] Ann Chim. tom. 61. p. 145.

[c] Mem. d'Arcueil, tom. 1.

The charcoal should have been previously heated red-hot in a crucible for half an hour, to expell all the gasses which it usually gives out on the first impression of the fire.

M. Cluzel[d] in his very elaborate memoir on this substance, finds that it may be easily prepared by mixing pyrites pulverized and heated to expell all the moisture, with twice its weight of charcoal, previously calcined by itself in a close vessel for a considerable time, putting the mixture in an earthen retort, and heating it very intensely, and receiving the product in water cooled by ice externally.

The physical and chemical properties of the alcohol of sulphur are the following. It is a limpid fluid either colourless or with a slight tinge of green or yellow, which may be entirely removed by redistillation: its specific gravity is 13. water being 10. Its smell is very strong, fetid, sulphureous, and pungent; its taste is very sharp and cool. When exposed to the air it evaporates full as soon as rectified ether, and produces a more intense cold. It kindles readily when brought near any burning body, and gives a large white flame yellowish at last, and spreads a suffocating smell of sulphureous acid, and its vapour during combustion deposits on the adjacent bodies a yellow substance exactly resembling sulphur. It leaves a black residue, combustible and resembling charcoal.

The water in which the alcohol is condensed during its preparation, seems to hold a very small portion of it in solution sufficient to retain the peculiar smell, and the property of precipitating several metallic solutions; those of lead giving an orange yellow precipitate, those of corrosive sublimate, a white, and those of tin, brick red: it does not redden litmus. Ammonia dissolves it with some ease and becomes of a yellow colour, which it gives to all metallic precipitates made with this alkali thus altered. If some of the alcohol of sulphur is put in a vessel of water and the vessel is put in an air pump, when part of the atmospherical pressure is removed, the alcohol assumes the form of gas which rises through the body of the water in large bubbles, and if the pressure is restored they immediately condense again on the water, and fall to the bottom unmixed with it.

If a little alcohol of sulphur is passed up a barometer that stands at 30 inches the mercury immediately falls to 19.6 inches, at 55°. therm. so that this fluid could not exist in any but a gasseous state at a pressure of no more than about 10.4 inches.

Alcohol of sulphur is not altered by passing through a red-hot tube, but its heated vapour burns with ease in common air when kindled. On the other hand oxygen holding the vapour of this fluid in solution, detonates with extreme violence.

Nitrous gas impregnated with the vapour of this fluid burns with uncommon splendour equal to zinc. Alcohol of sulphur will dissolve a little more sulphur without much apparent change, except in colour, which is rendered yellower.

When alcohol of sulphur is heated with a solution of fixed alkali confined in a strong vessel to prevent the escape of the alcohol, it entirely dissolves in the alkali, except a little charcoal, and a deep amber coloured liquid results, which gradually becomes a solution of sulphuretted hydrogen.

The nitric, muriatic, and sulphuric acids have no action on it in the cold. When heated, nitric acid partly decomposes it. Sulphureous acid gas and alcohol of sulphur heated together, only produce a mixed gas. Oxymuriatic acid slowly decomposes alcohol of sulphur. It dissolves easily in warm olive oil, some charcoal is deposited, and the mixture crystallizes speedily and regularly. Alcohol added to alcohol of sulphur immediately resolves it into two portions, one of which is a perfect solution and is precipitable by water. Ether also causes one portion to crystallize immediately and dissolves the rest.

Much difference of opinion exists on the composition of alcohol of sulphur. Messrs. Clement and Desormes consider it as a simple combination of sulphur and charcoal, and as they find no sulphuretted hydrogen, they consider it as a proof of the absence of hydrogen altogether. The absence of sulphuretted hydrogen they consider as proved by the total condensation of the alcohol of sulphur, when after having been vaporized through water by abstracting three fourths of the pressure of the air, this pressure is again restored. Sulphuretted hydrogen under similar circumstances would be dissolved in the water through which it is vaporized, and water thus saturated would give up very little of the gas under such a diminished pressure.

Another proof of the absence of sulphuretted hydrogen is this: if a little of the alcohol of sulphur is put into a vessel containing a solution of acetited lead and part of the atmospherical pressure is removed, the alcohol of sulphur is vaporized through this solution without blackening it. If the alcohol is long shaken with the solution it finally becomes brown but not black.

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[d] An. Chim. tom. 83 and 84.

M. A. Berthollet on the other hand considers this singular substance as a compound of hydrogen and sulphur only. He observes that no residue is left on burning it in the open air, but if the combustion is stopped, no other solid appears than pure sulphur. He considers the existence of hydrogen in this liquid as sufficiently proved, by the water through which it is vaporized acquiring all the properties of sulphuretted hydrogen. He is unable to detect any charcoal in the residue that is left after the spontaneous evaporation of all the volatile part of this liquid, but asserts that it is mere sulphur which may be totally sublimed. He observes that this substance when gassified and mixed with oxygen gas, detonates most violently so as to break very thick glass vessels; but by employing a very small quantity and detonating over lime-water, no precipitate is produced. Further, if some of the liquid is digested with oxymuriatic acid, the latter loses its smell; and if fresh quantities of the acid are successively added, a solid residue is finally left, which has the colour and consistence of sulphur, but in which no charcoal can be discovered. Neither is any charcoal removed by the oxymuriatic acid, for no carbonic acid is generated by its action.

He likewise observes that a solution of potash shaken with a little of the alcohol of sulphur finally becomes a hydro-sulphuret of potash, with an excess of sulphur, but no charcoal nor carbonic acid appears. When alcohol of sulphur is distilled with water at a heat of 86° to 96° Fahr. and in an apparatus quite free from air, the first product is a gas exactly similar to that produced by the spontaneous evaporation of the liquid, which has the smell of sulphuretted hydrogen, burns blue in the air, detonates strongly with oxygen, is speedily absorbed by water, rendering it milky by the deposition of sulphur, and produces a solution resembling entirely that of sulphuretted hydrogen. After this gas has passed away a transparent colourless fluid comes over, which swims in drops on the surface of the water. If the heat is raised to 112°. and kept up for some time, all that remains of the alcohol of sulphur is a mass that crystallizes on cooling, and may finally be sublimed like sulphur.

Several apparent varieties of the alcohol of sulphur are found according to the rapidity with which the sulphur is sent through the hot charcoal; all these the author considers as different combinations of sulphur and hydrogen in various proportions.

Besides the gas and the liquid alcohol of sulphur obtained in the process of subliming sulphur through hot charcoal, a good deal of the sulphur frequently passes through, and congeals on cooling. This sulphur M. A. Berthollet observes differs from common sulphur which has been merely melted, being lamellar, light, puffy, of a golden yellow, and when again fused giving out sulphuretted hydrogen gas, and containing no charcoal. This therefore he considers as a *Solid Hydroguretted Sulphur*. In this respect it resembles the precipitated sulphur produced by the action of an acid on a solution of an alkaline sulphuret.

The source of the hydrogen in the formation of this liquid the author attributes to the *Charcoal*, which though previously heated *per se* most intensely, is still able to furnish hydrogen to the sulphur sublimed through it. The charcoal also retains a portion of the sulphur after the operation; so that the author's opinion is that charcoal consists of pure carbon and hydrogen; and the sulphur coming in contact with it at a high temperature decomposes it, the greater part of the sulphur carrying off the hydrogen and condensing into the alcohol of sulphur, the sulphuretted hydrogen, and the solid hydroguretted sulphur that are produced; and a small portion of the sulphur remaining combined with the charcoal. The author also admits in order to account for the evident erosion of the charcoal, that the gas obtained from the solid product of the distillation, contains a portion of charcoal which is made manifest by combustion.

A very elaborate analysis of this singular liquid is given by M. Cluzel,[e] some of the particulars of which we shall relate. The mode of preparing it has been already mentioned. The liquors obtained by several successive operations were all united and rectified by a second distillation, which appears to make some slight alteration in some of its properties. This rectified alcohol of sulphur is totally and largely soluble in common alcohol, and the solution when dropped into water, at first renders it milky, but a large excess of water redissolves the precipitated portion, in which respect it resembles a solution of essential oil in alcohol; and which also proves that the precipitate which renders the water milky is not sulphur.

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[e] An. Chim. tom. 83 & 84.

M. Cluzel employed the same method for the analysis of this liquid which was originally used by Dr. Priestley for the analysis of spirit of wine, namely, by passing it in vapour over heated copper. Copper wire was introduced into a glass tube, with a small retort containing the alcohol of sulphur at one end, and an adopter and tubulated matrass at the other. The liquid was gradually vaporized over the heated copper. No gas was produced, and only a portion of the liquid was decomposed, the remainder condensing on the other extremity of the apparatus, but somewhat altered in appearance, being of a rose-colour, very acrid and volatile. The copper when withdrawn was become brittle and covered with a black matter resembling charcoal. By further analysis it was found to be a sulphuret of copper mixed with charcoal. The copper encreased from $\frac{1}{6}$ to $\frac{1}{8}$ in weight in the different experiments, and the copper, sulphur, charcoal, and undecomposed liquid together made up the sum of the weights of the alcohol of sulphur and copper employed, within about $\frac{1}{50}$th. of the whole.

The author substituted iron for copper with the hope of decomposing the whole of the alcohol of sulphur, but without success, a considerable portion of the liquid being condensed on the other side of the apparatus into the rose-coloured fluid already mentioned. He then endeavoured to analyze the liquid by combustion with oxygen gas in Volta's eudiometer, which would furnish sulphuric or sulphureous acid, carbonic acid, and water, in case the liquid was a hydro-carburetted sulphur.

M. Cluzel gives a new and very useful method of separating dry sulphureous and carbonic acid gasses; it is simply by the addition of a few bits of borax, which in less than an hour totally absorbs the sulphureous acid gas and leaves the carbonic acid untouched. The gassified alcohol of sulphur was then detonated with oxygen, and the results were sulphureous acid, carbonic acid, and a little water. We shall not follow the very complicated calculations required to deduce just inferences from this experiment, which was several times and very carefully repeated. But the author deduces from these the singular result, that the charcoal and sulphur if estimated from the allowed proportions in the carbonic acid, and sulphureous acid produced, would when added to the hydrogen of the water sensibly exceed the weight of the alcohol of sulphur employed. Hence he is led to infer that either sulphur or charcoal or perhaps both, in the state in which we know them, must be compound bodies, probably oxyds, and that they exist in their simple state in the alcohol of sulphur here examined. Besides radical sulphur, radical carbon and hydrogen, M. Cluzel finds a small quantity of azote in this liquid; and he also finds some difference in the relative proportions of these substances in the alcohol of sulphur, and the rose-coloured liquid above mentioned.

Experiments on the analysis of this singular liquid by means of copper, have been made by M. Vauquelin,[f] in illustration of those of M. Cluzel.

On 55 grammes of copper made red hot in a porcelain tube, were passed 23.135 gr. of the alcohol of sulphur reduced to vapour: 4.5 gr. of the liquid escaped decomposition, and was condensed in a bottle surrounded with ice; and about half a litre of gas was disengaged, which was only the air of the apparatus saturated with the gassified liquid, as it burned with a blue flame, and the residue of the combustion precipitated lime-water in flocculi, had the odour of sulphureous acid, but did not blacken acetite of lead, and therefore contained no sulphuretted hydrogen. After the experiment the copper was found entirely sulphuretted, and of a brilliant black colour, but quite homogeneous. Its weight was 72 gr. and therefore the copper had encreased 17 gr. in weight, which added to the 4.5 gr. of undecomposed liquid, leaves 1.6 gr. for the quantity of the liquid wafted away in gas in the air of the apparatus. The 4.5 of undecomposed liquid was then passed over 20 gr. of fresh copper, and this time no gas whatever was produced, so that the whole 4.5 remained in union with the copper. Hence it is inferred that if the copper is in sufficient quantity and the liquid be slowly vaporized through it, the whole would remain in union with the copper: and therefore an analysis of the black sulphuret remaining after the operation is sufficient to discover all the contents of the decomposed alcohol of sulphur. 10. grammes of the black sulphuret of copper were heated with nitric acid, which separated the metal, leaving 1.31 of a light black substance. The latter was then sublimed in a vessel filled with carbonic acid to prevent combustion, and yielded flowers of sulphur, leaving behind .34 of a black substance, which burnt like charcoal without any sulphureous smell, and left only a minute residue of copper.

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[f] An. Chim. 83.tom. p. 268.

The nitrous gas arising from the decomposition of the black sulphuret by the nitric acid, was found to contain no carbonic acid, as it did not render barytic water turbid. The sulphur sublimed from the black mass was collected, and that converted into sulphuric acid during the nitrous solution, was estimated by means of a barytic solution, and the quantity of sulphur thus obtained (allowing 41 per cent. of sulphur in sulphuric acid, and 34 per cent. of acid in sulphat of barytes) together with that of the charcoal actually procured, was almost exactly equal to the encrease of weight acquired by the copper in the first experiment. This slight difference of weight is so small as to be easily accounted for by the necessary loss in these operations, so that M. Vauquelin considers the alcohol of sulphur as containing no hydrogen, but as consisting merely of about 14 or 15 of charcoal, and 85 to 86 of sulphur.

The rose-coloured liquid obtained by M. Cluzel gave results almost exactly the same.

Therefore if this analysis be correct, it appears that this substance is accurately termed *Liquid Carburetted Sulphur*, that it contains probably no hydrogen, and no azote, but consists of six parts by weight of sulphur to one of charcoal.

A very valuable series of experiments on this singular liquid, the result of the united labours of Professor Berzelius and Dr. Marcet, together with experiments on the production of cold by its evaporation, by Dr. Marcet, have lately been published, from which we shall extract the following particulars, omitting chiefly those circumstances in which the observations of these eminent chemists confirm those of their predecessors in this enquiry.[a]

This liquid was prepared by slowly volatilizing sulphur through red-hot charcoal in a porcelain tube, and condensing the product in water. The fluid thus procured is at first of a pale yellow colour, and must be rectified by a second distillation.

Dr. Marcet advises the employment of a large earthen tube about one inch and a half in diameter, instead of the small porcelain tubes commonly employed. The process is always tedious, but with the large tube about half a pint of the liquor may be procured in the course of a day. The same tube can hardly ever be used twice. Fresh sulphur may be successively introduced whilst the distillation is going on, and without renewing the charcoal, as the occasional admission of air does not materially affect the process.

To rectify the liquid it must be distilled in a heat not exceeding 100° or 110°, and to prevent any moisture from rising, some muriat of lime may also be put into the retort. The liquid must be condensed in a receiver cooled with ice. Some sulphur remains in the retort. The specific gravity of the rectified liquid is 1.272; its expansive force at 30 in. bar and 53.5°. therm. is equal to the pressure of 7.36 inches of mercury, so that air to which it is admitted will dilate about one fourth of its volume. It boils briskly at 105°. to 110°. It does not congeal at 60°. below 0. It burns with a bluish flame, but without the deposition of any moisture.

The volatility of this liquid is very remarkable, being superior to that of ether, and hence it produces a greater degree of cold by evaporation than any other known fluid, as will be soon noticed.

This carburetted sulphur readily dissolves in alcohol and ether, and if it contain sulphur in solution, the latter is rapidly separated in spicular crystals. It readily mixes with and dissolves all oils and camphor. Neither mercury nor silver nor lead are at all altered by this liquid, provided it has been carefully rectified, to exclude the sulphur which it holds merely in solution when first prepared. The alkalies dissolve this liquid slowly, but totally.

The first set of experiments on the composition of this carburetted sulphur here described, have for their object to determine whether it contains any hydrogen. Some of the liquid was suffered to evaporate in oxygen gas of known purity, and previously dried by muriat of lime. This vapour-holding oxygen was exploded by the electric spark which acted vividly, and $\frac{1}{5}$ to $\frac{1}{6}$ of its volume disappeared, at the same time that traces of a condensed fluid appeared in the vessel, which soon produced as many white specks of sulphat of mercury. This experiment not being decisive, another mode was tried. Some dried oxymuriatic gas was passed through some of this liquid, and afterwards through water. The liquid absorbed the gas readily and abundantly, and acquired an orange hue, and a very peculiar smell. The water in which most of the liquid was condensed, contained a little muriatic and a vestige of sulphuric acid. But the greater part of the liquid remained unchanged after the absorption of the oxygen. In some days however it gradually acquired the smell of muriated sulphur.

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[a] Phil. Trans. for 1813.

Some of the liquid was passed in vapour through fused muriat of silver at a low red heat, but no change whatever appeared to take place in either substance. Hence they infer that the liquid contained no hydrogen, since if it had, the muriat of silver would have been decomposed, the hydrogen would have formed water with the oxygen of the muriat, and this would have united with a portion of the muriatic acid, and expelled it in the form of muriatic acid gas, with production of sulphuret of silver.

Various metallic oxyds, such as red oxyd of iron, oxyd of manganese, and oxyd of tin were ignited, and caused to receive in that state the vapour of the liquid, which was thus entirely decomposed, the metallic oxyds being converted to sulphurets, and the gasses acquiring a strong smell of sulphureous acid, but in none of these cases was any water produced.

From all these experiments, these chemists conclude that the carburetted sulphur contains no hydrogen.

The presence of carbon was the next point to be ascertained. For this purpose the gasseous residue of the combustion of the vapour of the liquid with oxygen gas was put in contact with water, and most of it absorbed, giving the water the taste and smell of sulphureous acid. Lime water absorbed part of the remainder, producing carbonate of lime; and the unabsorbed portion was detonated with fresh oxygen, and then produced a second precipitate with lime-water. This latter portion therefore was a gas that wanted more oxygen to become carbonic acid, or *Carbonic Oxyd*, and the two other portions were carbonic acid and sulphureous acid gas.

In attempting to fix the proportions of sulphur and carbon in this singular liquid, very considerable difficulties occurred, owing to its extreme volatility, and the imperfect action which the common modes of decomposition appeared to produce.

The method that succeeded the best was the following. A coated glass tube was laid in a sloping direction through a small furnace; to the upper end of the tube a small glass capsule containing some of the liquid was hermetically sealed; and to the lower, was fixed another small glass tube expanded in the middle and bent at the further end to convey any gas to the mercurial trough. The larger tube, which was laid across the furnace, was filled with red oxyd of iron coarsely pulverized, and the bulbous expansion of the lower tube was kept surrounded with ice and salt. The larger tube being made red-hot, and the upper capsule containing a weighed quantity of the liquid carburetted sulphur, the latter was heated very gently by a lamp placed near (but not beneath) it, and its vapour was made to pass slowly through the red-hot oxyd of iron. The process was so gradual, that it required six hours and a half to volatilize and decompose about 15 grains of the oil. Some previous trials had failed from hastening the process.

In this way the decomposition was so perfect that not a particle of the liquid sulphuret was condensed at the lower end of the apparatus, but the oxyd of iron (weighing ten times the liquid used) was partly converted to sulphuret of iron, having a yellow colour and a brilliant metallic lustre. This sulphuret was dissolved (and we presume totally oxygenated) by nitro-muriatic acid, the oxyd of iron separated by ammonia, and the sulphuric acid generated from the sulphur was combined with barytes by adding muriatic acid and muriat of barytes, and the sulphat of barytes washed, ignited and weighed. The mixed gas produced in the process was exposed for about an hour to the action of a small quantity of brown oxyd of lead enclosed in a capsule, and passed up through the mercury into the jar containing the gas. By this means all the sulphureous acid was absorbed, after which the carbonic acid was taken up by dry caustic potash, and no other residue was left than a little common air of the vessels.

In the above analysis therefore the sulphur originally contained in the liquid sulphuret of carbon was procured partly in the form of sulphat of barytes, and partly as sulphureous acid gas. The carbon also was obtained in the form of carbonic acid gas, and the sulphur and carbon added together as nearly equalled the weight of the liquid decomposed as can be ever expected in experiments of this kind. The carbon weighs 15.7 per cent. of the liquid, and the sulphur 84.83.

The data of these computations assumed by Professor Berzelius are, that 100. parts by weight of carbonic acid contain 27. of carbon: that 100 parts of sulphat of barytes contain 13.66 of sulphur, and that 100 parts of sulphureous acid gas contain 51 of sulphur.

Professor Berzelius proceeds to shew how closely this analysis coincides with the law of the combination of combustible bases, which he has laid down in his valuable and elaborate researches (for which see the article *Affinity* in in this appendix) which law is, that "when two "such bodies unite, the proportion in which "this combination takes place is such, that if "they be oxydated to a certain degree, they "will either absorb an equal quantity of oxygen, "or one will absorb two, three, four, &c. times "as much as the other." In the present instance the oxygen which would convert the sulphur to sulphureous acid would be exactly twice the quantity required to convert the carbon to carbonic acid, provided a slight change were made in the above mentioned numbers expressing the composition of the liquid, making the carbon 15.47 per cent. and the sulphur 84.53.

Carburetted sulphur appears by further experiments to be capable of some degree of combination with alkalies, earths, and metallic oxyds, forming compounds, to which Professor Berzelius proposes to give the name of *Carbo-Sulphurets.*

When a glass bulb with a small orifice filled with liquid carburetted sulphur is introduced into a vessel of ammoniacal gas, a contraction of bulk takes place, and a yellow saline uncrystallized substance is deposited, which contains the whole of the carburetted sulphur saturated with ammonia where the latter abounds. If this substance is sublimed without changing the vessel, it condenses unaltered in a cooler part of the vessel; but the moment it has contact with air it absorbs moisture, and is partially decomposed, and then it gives when sublimed, crystals of hydrosulphuret of ammonia. Carbonic acid is doubtless generated at the same time.

Lime heated in an atmosphere of vaporized liquid carburetted sulphur appears also to contract some union with it, but this compound also is decomposed by moisture.

We shall add a few particulars of Dr. Marcet's experiments on the very intense cold produced by the evaporation of liquid carburetted sulphur.

If the bulb of a small spirit thermometer be closely covered with a bag of fine flannel, or better, with a piece of fine lint, and a few drops of the liquid poured on it, the thermometer (if before at about 60°) rapidly sinks to near 0°.

But if the thermometer bulb thus wetted be introduced into the receiver of an air-pump, and the vessel exhausted, the temperature in one or two minutes will descend from summer heat to —70° or —80, that is about 40 degrees below the freezing point of mercury. Therefore, if instead of a spirit thermometer, a small bulb containing mercury be used, this metal may be easily frozen, and the phenomena attending its congelation may be seen with great convenience. If the air be very damp this somewhat impedes the experiment.

SULPHURIZED MURIATIC ACID.

This singular compound, discovered by Dr. Thomson, has been already described in the Chim. Dict. It is considered by Sir H. Davy (agreeably to his theory) as a compound of sulphur and chlorine, and may be immediately prepared by heating a little sulphur in a retort filled with chlorine. The sulphur and the chlorine unite and form a fluid, which distills into the colder part of the retort. It does not redden perfectly dry litmus paper. When agitated with water, much sulphur is deposited, and the water contains muriatic and sulphuric acid.

According to Sir H. Davy's experiments, 10 grains of pure sulphur absorb about 30 cubic inches of chlorine, so that the compound contains by weight 30 parts of sulphur to 67 of chlorine. The compound contains a *maximum* of chlorine, but may be united to an additional portion of sulphur.

This compound has been examined by M. Amadeé Berthollet.[a] The general facts found by this able chemist agree with those of Dr. Thomson. When this liquid is shaken with a little water, the mixture acquires very soon a boiling heat, and is rapidly decomposed. The water contains muriatic, sulphureous, and a little sulphuric acid, and sulphur precipitates, which when well washed differs in no respect from common sulphur, and is not (as Dr. Thomson has conjectured) a protoxyd of sulphur. To examine whether the sulphurized muriatic acid contained any sulphureous acid before mixture with water, M. A. Berthollet passed a current of sulphuretted hydrogen through the liquid, but without any apparent decomposition and deposition of sulphur from the gas, which might have been expected had any sulphureous acid been contained. On the other hand, when the gas is received in water it is immediately decomposed, the sulphuretted hydrogen holding in solution a portion of the sulphurized liquor mutually unite, scarcely any of the gas remains uncondensed, sulphur is deposited, and a sensible quantity of sulphuric acid is formed.

When pure dry mercury is shaken with the sulphurized muriatic acid, a very great heat is excited, and the whole is changed to a grey pulverulent mass. This when thrown into water is mostly dissolved, and the solution contains sulphat and muriat of mercury in a high state of oxydation.

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[a] Mem. d'Arcueil, tom. 1.

The fact of the acids being only developed when water is added, may be readily explained on Sir H. Davy's theory of the constitution of muriatic acid. If the sulphurized muriatic acid is a mere compound of sulphur and chlorine, water will furnish oxygen to the sulphur, and hydrogen to the chlorine, and thus the sulphur will be acidified, and the chlorine will be changed to muriatic acid.

Professor Berzelius considers this compound as a compound of muriatic acid and *Oxyd of Sulphur*, a substance whose existence is still very hypothetical, as it cannot be produced in any but a compound form : when water is added, the oxyd is decomposed into the sulphur that precipitates, and the sulphureous acid that remains in solution, one portion being oxygenated at the expence of the other. This oxyd of sulphur he considers as being composed of 100 of sulphur to 50 of oxygen, which is half the proportion of oxygen to that in sulphureous acid.

SULPHURETTED HYDROGEN. HYDROSULPHURETS.

Some valuable observations on this gas have been made by Sir H. Davy,[a] and by Messrs. Gay Lussac and Thenard.[b] The latter chemists observe, that when this gas is made by digesting the sub-sulphuret of iron with dilute sulphuric acid, the gas is always mixed with a quantity of hydrogen, which is less in the first than in the latter portion obtained. This may be ascertained by shaking the gas in lime-water, which absorbs the sulphuretted hydrogen, and leaves the pure hydrogen. Neither can this gas be prepared pure by heating sulphur in hydrogen gas, as a great portion of the latter always remains unchanged. The best way of obtaining sulphuretted hydrogen is either by digesting sulphuret of antimony in hot concentrated muriatic acid; or by treating the solid hydrosulphurets of potash or soda with a dilute muriatic or sulphuric acid. Care must however be taken that the alkalies are not at the same time partially carbonated, as this would introduce carbonic acid into the gas obtained. Sulphuretted hydrogen contains exactly its own volume of hydrogen, as is proved both by there being no change of bulk when sulphur is heated in hydrogen; and inversely, when the sulphur is extracted from a given portion of sulphuretted hydrogen. This is very conveniently and accurately performed by heating a piece of clean tin in the gas for half an hour at a low red-heat. All the sulphur is thus extracted, and the remaining gas is pure hydrogen of precisely the same volume as the sulphuretted hydrogen employed. The specific gravity of sulphuretted hydrogen dried by muriat of lime, is given by these chemists as 1.1912 (common air being unity) and hence that of hydrogen being .073199, the composition of sulphuretted hydrogen is 93.855 parts by weight of sulphur, and 6.145 of hydrogen, which is nearly 15 of sulphur to 1 of hydrogen. Sulphuretted hydrogen is soluble in many liquids. Strong muriatic acid will dissolve 3 times its volume at 52°. therm. and 29.92 in. bar. Sulphuric acid diluted with its own weight of water will dissolve 1½ times its volume at the same pressure and temperature, and water full 3 times. It is necessary for this however that the gas be quite pure, for if mixed with hydrogen the quantity dissolved is much less. When 100 measures of sulphuretted hydrogen are mixed with 50. of oxygen, and exploded by the electric spark, both gasses disappear, water is produced and sulphur deposited : when 150 measures of oxygen are used, the products are about 87 measures of sulphureous acid gas besides the water produced, so that both the component parts are oxygenated.[c]

Sir H. Davy gives as the result of his most accurate observations,[d] that 100 cubic inches of sulphuretted hydrogen at a medium pressure and temperature weigh 36.5 grains, and if it contains its own bulk of hydrogen (of which 100. cubic inches weigh 2.27 grains) it must be composed, by weight, of 2.27 parts of hydrogen, and 34.23 of sulphur, or, in 100. parts, it consists of 6.219 hydrogen, and 93.781 sulphur, which is very exactly 1 of hydrogen to 16 of sulphur. When sulphuretted hydrogen is exposed to common electricity, or if platina wires be ignited in it by the voltaic apparatus, it is rapidly decomposed, sulphur is deposited, and an equal volume of hydrogen remains.

M. Thenard has some observations on the triple compounds of sulphur, sulphuretted hydrogen and a base.[e] When a saturated hydrosulphuret (or a base saturated with sulphuretted hydrogen) is heated with sulphur, a strong effervescence ensues, much of the sulphur is dissolved, and an equivalent portion of the sulphuretted hydrogen escapes in a gasseous form. If on the other hand, the hydrosulphuret is not saturated with sulphuretted hydrogen, when heated with sulphur much of it is still dissolved, but no sulphuretted hydrogen escapes.

The saturated hydrosulphurets when boiled without addition, give out more or less of this sulphuretted hydrogen, and thus are decomposed partially or entirely. The hydro-sulphuret of magnesia is compleatly decomposed at this heat; that of lime almost entirely; the hydrosulphurets of potash or soda are partially so, and become very alkaline, but still retain so much sulphuretted hydrogen as to give it out abundantly on being heated with sulphur.

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[a] Elements of Chemistry.

[b] Recherches, tom. i. p. 192.

[c] Dalton.

[d] Phil. Trans. for 1812.

[e] An. Chim. tom. 83. p. 132.

The hydrosulphuret of ammonia is deposited in the form of needle-shaped crystals, by passing equal portions of sulphuretted hydrogen and ammoniacal gas into a dry vessel cooled by ice externally. This hydrosulphuret of ammonia is at first colourless, but soon turns yellow when exposed to the air, and then by partial abstraction of the hydrogen contains an excess of sulphur relatively to the hydrogen. It is also very volatile, and sublimes even in a common temperature to the top of the vessel in which it is kept, and thus it may be obtained separate from that portion which has undergone partial decomposition.

The sulphuretted hydrosulphuret of ammonia has an oily consistence when saturated with sulphur, which is effected merely by digesting sulphur with Boyle's fuming liquid (or hydrosulphuret of ammonia) at a common temperatuse. When this is diluted with water, much sulphur is precipitated, even if liquid ammonia be previously added. This saturated sulphuretted hydrosulphuret of ammonia gives out vapours in the air, but much less than Boyle's liquid; which latter will give out a very dense vapour for a long time when exposed to oxygen, but scarcely any in azote or hydrogen.

SULPHUREOUS ACID.

When sulphur is burnt in a given quantity of dry oxygen gas, the sole product is sulphureous acid gas. Some condensation always takes place, but it is variable, and in small quantity when the sulphur is the purest. It therefore is most probably owing to some hydrogen remaining in the sulphur, so that if sulphur were quite pure, it would probably be converted into sulphureous acid gas by oxygen without any change of bulk. Therefore, by ascertaining the weight of a given volume of sulphureous acid gas, and deducting from it the weight of an equal bulk of oxygen the remainder will be the sulphur. Thus 100 cubic inches of sulphureous acid gas weigh at a mean pressure and temperature 68 grains, and 100 cubic inches of oxygen gas weigh 34 grains, leaving also 34 for the weight of the sulphur. Hence it is most probable that sulphureous acid gas is composed of equal weights of sulphur and oxygen, and the absolute weight of each in a given quantity of the acid gas, is equal to that of the same volume of oxygen.

Another proof of the constitution of sulphureous acid is obtained from the combustion of sulphuretted hydrogen in Volta's eudiometer.[a] This compound contains exactly its own bulk of hydrogen, and 100. cubic inches consist (as above mentioned) of 34.23 grains of sulphur, and 2.27 grains of hydrogen. Now when sulphuretted hydrogen is exploded with abundance of oxygen, the products are sulphureous acid gas and water; and 2 measures of sulphuretted hydrogen require 3 measures of oxygen for this purpose, or 100. require 150. of oxygen. Therefore, according to the well known constitution of water, the 100. cubic inches of hydrogen (contained in the same bulk of sulphuretted hydrogen) require 50. cubic inches of oxygen to produce water, which would leave 100. cubic inches of oxygen, weighing about 34. grains, to form sulphureous acid with 34.23 grains of sulphur, which are nearly equal weights.

Professor Berzelius ascertains the composition of sulphureous acid from the sulphate of barytes, as mentioned in the article *Affinity* in this appendix, which gives the component parts of this acid to be 100. of sulphur, and 97.83 oxygen. These differ but little from being equal parts of each.

SULPHURIC ACID.

Much information has been lately given by experimental researches on the constitution of this most important acid, and the theory of its formation. It has long been known that the most concentrated acid which can be obtained in a separate state, contains a considerable quantity of water in its composition, which may be expelled when it enters into chemical union with any base, a fixed alkali for example, and it is on this principle that Mr. Kirwan formed his tables for the proportions of real acid in liquid sulphuric acid of different degrees of dilution. Sulphuric acid therefore is composed of sulphur, oxygen, and water, the latter of which it is capable of giving up when it enters into combination with a base.

The proportion of oxygen to sulphur in sulphuric acid appears by a variety of experiments to be $1\frac{1}{2}$ times as much as that in sulphureous acid, and in the latter it is as already mentioned, nearly, if not exactly, equal to the sulphur. So that if 30 grains of sulphur take 30 grains of oxygen to become sulphureous acid, it will require 45 grains of oxygen to form dry sulphuric acid such as exists in the neutral sulphats after ignition. Sir H. Davy estimates the water in 100 parts of the most concentrated liquid sulphuric acid to be about 19 in 100, and hence the composition of liquid sulphuric acid in 92 parts will be as follows:

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[a] Dalton's System, vol. ii.

$$\left.\begin{array}{lr}\text{Sulphur . .} & 30\\ \text{Oxygen . .} & 45\end{array}\right\} 75\ \text{Dry sulphuric acid}$$

$$\left.\begin{array}{lr}\text{Hydrogen .} & 2\\ \text{Oxygen . .} & 15\end{array}\right\} 17\ \text{Water}$$

92 Liquid sulphuric acid

If this be correct, the sulphur will unite with three portions of oxygen (45) to produce the acid, and this with one portion of oxygen (15) in the water essential to its separate state, which will agree with the opinion advanced by Berzelius, that the oxygen of the water in definite compounds is an equal portion of that in the other constituents. *(See Affinity in this appendix.)* Since sulphureous acid consists of sulphur with two portions of oxygen, and sulphuric acid, of sulphur with three portions, and since sulphureous acid gas occupies the same space as its oxygen alone would fill, it must therefore follow that whenever sulphuric acid is partially decomposed, it will resolve itself into two parts in volume of sulphureous acid gas, and one volume of oxygen gas. This is actually found to be the case by experiment: for when the strongest sulphuric acid is vaporized by heat, and in this state passed through a red-hot porcelain tube, it is resolved into a gas consisting of two volumes of sulphureous acid and one volume of oxygen, and a liquid condenses, which is the same as dilute sulphuric acid. It would appear therefore in this experiment that only a portion of the acid is decomposed, but none of the water.

When a solution of sulphureous acid gas recently made, is heated, nearly if not entirely the whole of the gas may be again expelled by long boiling; but if it be exposed to the air for some time, it loses its peculiar smell, becomes strongly sour, and is converted into a weak solution of sulphuric acid, which may be concentrated by evaporation.

The experiments of Professor Berzelius *(see Affinity in this appendix)* very nearly agree with the composition of sulphuric acid above mentioned. He shews that the sulphuret of lead is totally converted into neutral sulphat of lead by the action of nitric acid, that is to say by the addition of oxygen, and therefore that the sulphur and the lead are in the same relative proportions to each other in both preparations. Hence by previously ascertaining the quantity of oxygen contained in the suboxyd of lead which is the base of the sulphat, and by finding the total addition of oxygen required to convert the sulphuret into sulphat, the oxygen required by the sulphur alone to produce the sulphuric acid of the sulphat is readily found. This gives the composition of dry sulphuric acid to be 39.92 of sulphur to 60.02 of oxygen, or almost exactly 2 parts of sulphur to 3 of oxygen, which agrees as nearly as can be expected with the proportions before given.

A very instructive memoir on the decomposition of the metallic sulphats by heat, is given by M. Gay Lussac.[a] All these salts are decomposable by a heat more or less intense, but the products of this operation vary according to the force of the affinity of the metals for sulphuric acid. The soluble sulphats in which the acid is but little condensed, give only sulphuric acid by distillation. But those that retain the acid strongly, and are at the same time insoluble, give out their acid decomposed into sulphureous acid and oxygen gasses: and the sulphats that are acid and soluble, but yet retain the acid with considerable force, give out their acid when heated, partly as sulphuric acid, and partly as sulphureous acid and oxygen. Some of the experiments are as follows. Sulphat of copper was distilled in an earthen retort in a furnace capable of giving a very intense heat. It had been previously calcined to expell the water. The products were a most abundant stream of mixed gas, which continued for an hour without abatement. On encreasing the heat the gas again appeared, and different portions of it were reserved for analysis. At the last the heat was urged with great violence as long as any thing was given out. The copper was found reduced and fused in a button at the bottom of the vessel. On examining the gas obtained at different periods of the distillation, it was found to consist very uniformly of about 32.5 per cent. (in volume) of oxygen and the rest sulphureous acid, except the last portion of all, which contained as much as 92.4 of oxygen, and was obviously produced at the time of the reduction of the oxyd of copper in the extreme heat. Therefore (setting aside the last portion) it appears that in the sulphat of copper, the sulphuric acid soon begins to be decomposed when heated, and continues this change uniformly as long as any acid remains.

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[a] Mem. d'Arcueil, tom. 1.

The same was observed from alum strongly heated, the gas being a pretty uniform mixture of about two parts in volume of sulphureous acid, and one part of oxygen, and this continued without change to the end of the process, as the base of this sulphat was not itself deoxygenated by the heat.

Sulphat of iron has long been employed to yield sulphuric acid by its distillation, but besides the sulphuric, it also gives out much sulphureous acid gas. This was long supposed to arise from the higher degree of oxygenation which the metal acquires in the process, (which is actually the case) but it was observed by Chaptel that oxygen gas was also given out, and hence only a portion of the acid of this salt is obtainable by distillation unchanged, and the rest appears in the form of sulphureous acid and oxygen, as in the distillation of sulphat of copper.

The sulphats of manganese and zinc also give out most of their acid decomposed.

When sulphuric acid is digested on tin, antimony or bismuth, two sulphats are formed, one, very soluble, and with a great excess of oxyd; the other, little soluble, and with excess of oxyd. The former of these yields much of its acid unaltered in distillation; the latter gives it out in the form of its constituent parts, oxygen and sulphureous acid.

The sulphat of silver, which is one of the insoluble sulphats that retains its acid strongly, gave out its acid decomposed, and the metal was reduced.

Sulphat of mercury underwent a similar change.

With regard to the sulphats of the fixed alkalies and of some of the earths, they are undecomposeable by distillation *per se* when neutral; but of some of the acid sulphats so much of the acid is decomposed as constitutes the excess beyond the point of neutralization. Thus the acid sulphat of potash gives out, on heating, part of its acid unchanged, and part in the form of sulphureous acid and oxygen, till it is brought to the neutral sulphat, when no further change occurs.

But even the neutral sulphats will be partially decomposed, when distilled with vitreous phosphoric or boracic acid; and the products therefore will be, not sulphuric acid, but its elements, sulphureous acid and oxygen.

The theory of the formation of sulphuric acid by the combustion of sulphur and nitre, as now so generally practised, has been the subject of much controversy. The common opinion that the nitre acts merely by furnishing oxygen to the sulphur, is fully confuted by the fact that sulphur burnt in oxygen gas does not produce sulphuric acid, but only a mixture of sulphureous acid gas and oxygen; and also, that the quantity of nitre found sufficient for the purpose would not furnish nearly enough oxygen to the sulphur.

Some interesting remarks on this subject are given by Messrs. Desormes and Clement.[b] These chemists shew that even when the nitre is one fifth of the sulphur (which is the largest allowance) it will not furnish one fifth enough oxygen to acidify the sulphur; and the sulphat of potash alone which remains in the residue contains as much oxygen as all the nitre.

They observe that when the mixture of nitre and sulphur is burning in the pots of the leaden chamber in which sulphuric acid is made, the nitric acid is obviously not entirely decomposed, for much red nitrous acid vapour is diffused in the chamber along with the sulphureous acid. The combustion of the mixture in the pots therefore first produces a mixture of nitrous acid gas and sulphureous acid gas, together with the vapour of water, but these acid gasses cannot subsist together for a moment (when moist) without mutual decomposition into sulphuric acid and nitrous gas, which therefore happens in the body and upper part of the chamber. A condensation of the sulphuric acid vapour then takes place, which is absorbed by the water on the floor. This forms a partial vacuum, that is filled by external atmospherical air, which last is in its turn decomposed by the nitrous gas absorbing its oxygen and becoming nitrous acid gas. This again is ready to furnish oxygen to a fresh portion of sulphureous acid gas diffused in the chamber, which again produces sulphuric acid that condenses in the water below, and nitrous gas, and occasions a vacuum supplied from the air from without; and the gas, now become nitrous acid gas, continues as before to compleat the oxygenation of fresh portions of sulphureous acid.

The nitric acid therefore is constantly in a state of successive decomposition and recomposition by the successive portions of oxygen which it furnishes to the sulphureous acid, and again by the re-absorption from the air of the oxygen which it thus loses. These changes are very well shewn by introducing into a large open glass globe first a quantity of sulphureous acid gas, then adding a small quantity (about $\frac{1}{20}$) of nitrous gas, which will immediately produce red fumes of nitrous acid gas, followed by a white dense vapour which gradually condenses on the inner surface of the glass in shining stellated crystals, and the air of the vessel again becomes transparent. If a few drops of water are then introduced, the crystals dissolve with great heat, and the nitrous gas is again expelled, which directly changes as before into red nitrous acid vapour, and the same round of chemical action goes on till all the oxygen of the air in the vessel is exhausted, or till all the sulphureous acid gas is consumed.

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[b] An. Chim. tom. 59.

The presence of water is essential to the formation of sulphuric acid, for if sulphureous acid gas and nitrous acid gas both perfectly dry be brought in contact, no action ensues: but the least portion of moisture causes them to condense into the solid crystalline compound above described; and a little more water generates liquid sulphuric acid, and the nitrous gas is expelled. Sometimes, in making the above experiment, the decomposition of the nitrous acid gas proceeds further than the generation of nitrous gas, and produces nitrous oxyd. It does not appear precisely what is the reason of this variety of effect; but when it does occur it stops the further acidification of the sulphureous acid, as the nitrous oxyd will not spontaneously reabsorb from the air the oxygen which it has lost.

We shall now give Mr. Dalton's table of the strength of sulphuric acid at different densities, the results of his own experience in this acid for several years.[c]

Table of the quantity of real acid in 100 parts of liquid sulphuric acid, at the temperature of 60°.

Acid per cent. by weight.	Acid per cent. by measure.	Specific gravity.	Boiling point.
100	unknown	unknown	unknown
81	150	1.850	620°
80	148	1.849	605°
79	146	1.848	590°
78	144	1,847	575°
77	142	1.845	560°
76	140	1.842	545°
75	138	1.838	530°
74	135	1.833	515°
73	133	1.827	501°
72	131	1.819	487°
71	129	1.810	473°
70	126	1.801	460°
69	124	1.791	447°
68	121	1.780	435°
67	118	1.769	422°
66	116	1.757	410°
65	113	1.744	400°
64	111	1.730	391°
63	108	1.715	382°
62	105	1.699	374°
61	103	1.684	367°
60	100	1.670	360°
58.6	97	1.650	350°
50	76	1.520	290°
40	56	1.408	260°
30	39	1.30+	240°
20	24	1.200	224°
10	11	1.10—	218°

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[c] New System.

In the above table the first line is a substance which probably does not exist, being the pure acid, supposed to be in a liquid state and free from all water. It is composed of single atoms of sulphuric acid, and the relative weight of each atom is given by Mr. D. to be 34 times that of an atom of hydrogen. This number is derived from the assumed composition of an atom of sulphuric acid to be one atom of sulphur (13) with 3 of oxygen (21). The atom of sulphur again is derived from the actual composition of sulphureous acid, which is estimated at 48 parts by weight of sulphur and 52 oxygen; and it is assumed to consist of 2 atoms of oxygen (14) to 1 of sulphur and 52 : 48 :: 14 : 13 which gives the relative weight of the atom of sulphur to be 13. (hydrogen being always unity.)

But on the other hand, if sulphureous acid consists of equal weights of sulphur and oxygen, the atom of sulphur will be 14. and the atom of sulphuric acid will be $14 + 21 = 35$, being 1 atom of sulphur and 3 of oxygen.

Mr. Dalton infers that the acid of 81. per cent. by weight, or 1.85 specific gravity, is composed of an atom of real sulphuric acid and an atom of water. This is nearly the mean of each estimation of the atom of sulphuric acid, for if it is taken at 34. an atom of this and an atom of water would indicate a strength of 81.4 per cent. of real acid; and if it is taken at 35. it will indicate 80.95 per cent. As this acid of 1.85 specific gravity is the strongest liquid sulphuric acid that can be procured in an uncombined state, and distills unchanged without becoming more concentrated, and is a well defined specific compound, there is great reason to suppose it to consist of some simple definite proportion of acid and water.

The next definite compound of sulphuric acid and water, according to Mr. Dalton's system, will be that which is composed of 1 atom of real acid and 2 atoms of water, and this forms the acid of 68. per cent., by weight, of acid and 1.78 specific gravity. It is worthy of remark that this is the acid which Mr. Keir has discovered to possess the remarkable property of congealing at 32° and remaining unthawed at any temperature below 46°, as we noticed in our former article of *Sulphuric Acid (Chem. Dict.)* If the acid be as little as 1 per cent. stronger or weaker, this remarkable property of remaining congealed at a comparatively high temperature is lost.

No peculiar properties have hitherto been discovered in any other of the definite points of dilution of the acid. The acid of 58.6 per cent., by weight, of real acid contains by Mr. Dalton's estimation 1 atom of acid to 3 atoms of water; that of 30 per cent. contains 1 atom of acid to 10 of water; that of 20 per cent. contains 1 of acid to 17 of water; and that of 10 per cent. contains 1 of acid to 38 of water.

Mr. Dalton's table differs considerably from that of Mr. Kirwan. As the specific gravity encreases but little in proportion to the strength of the acid in the more concentrated mixtures, Mr. Dalton observes, that in these it is safer for practical utility to depend on the temperature at which the acids boil to form a ready estimate of their strength, as this gives a greater range for examination.

We shall conclude this article with a table of the strength of different mixtures of sulphuric acid and water drawn up for practical purposes of M. Vauquelin, from experiments made with great care.[h] This table may be of service to the English chemist, though it is chiefly calculated for an instrument (Beaume's areometer) which is but little employed in this country, and of no precise authority. M. Vauquelin's table would have been perhaps rather more useful if the standard or concentrated acid which he employed had been somewhat stronger; for as it is, it wants much of the strength of the most concentrated acid, and is somewhat lower than the strong sulphuric acid usually sold in this country. As this eminent chemist asserts that the experiments were most carefully made, no doubt can be entertained of their accuracy.

Table of the proportions (by weight) of standard sulphuric acid of 1.842 specific gravity and of water, in 100. parts of sulphuric acid of different degrees of dilution—Temperature, 12°. Reaumur. = 59°. Fahr.

Beaumé's Areometer.	Specific Gravity.	Standard Acid.	Water.
66.	1.842	100.00	0.
60.	1.725	84.22	15.78
55.	1.618	74.32	25.68
50.	1.524	66.45	33.55
45.	1.466	58.02	41.98
40.	1.375	50.41	49.59
35.	1.315	43.21	56.79
30.	1.260	36.52	63.48
25.	1.210	30.12	69.88
20.	1.162	24.01	75.99
15.	1.114	17.39	82.61
10.	1.076	11.73	88.27
5.	1.023	6.60	93.40

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[h] Ann. Chim. tom. 76. p. 260.

SULPHATS, *Alkaline and Earthy.*

The manufacture of sulphat of magnesia or Epsom salt, as practised at Lymington in Hampshire, is thus described by Dr. Henry,[a] on the authority of Mr. St. Barbe the proprietor. Sea-water, concentrated by spontaneous evaporation in the air, is boiled down to dryness in pans, and the mass is taken out entire and removed into troughs with holes at the bottom, where the mother liquor drains through, leaving the muriat of soda nearly pure. The Epsom salt is made from this mother liquor in the winter season, by a very simple process. The mother liquor is boiled for some hours in the salt pans, and the impurities are removed by skimming. During the evaporation a portion of common salt separates, which is removed. The evaporated liquor is then poured into wooden coolers 8 feet long, 5 wide and 1 foot deep. In these it remains twenty-four hours, during which time, if the weather prove clear and cold, the sulphat of magnesia crystallizes at the bottom of the cooler in quantity equal to about one-eighth of the boiled liquor. The uncrystallizable fluid is then let off through plug-holes at the bottom of the coolers; and the Epsom salt is drained in baskets. This is termed *single* Epsom salt, and after a second solution and crystallization it is termed *double* Epsom salt. Four or five tons of sulphat of magnesia are obtained from a quantity of brine which has yielded 100 tons of common salt.

Sulphat of Barytes. Many of the methods of decomposing this salt have been already mentioned; the following is given by Goettling.[b] Mix together in fine powder eight parts of native sulphat of barytes, two parts of muriat of soda, and one part of charcoal powder. Press the mixture hard into a Hessian crucible, and expose it for an hour and a half to a red heat in a wind furnace. When cold, reduce the mass to powder and boil it for a short time in sixteen parts of water; filter the lixivium and keep it in well stopped bottles. To prepare muriat of barytes from this lixivium, add muriatic acid as long as any sulphuretted hydrogen gas is extricated. Evaporate the liquid to a pellicle, and set it by to crystallize, when the muriat of barytes will separate. Again evaporate the liquid part, removing the muriat of soda that forms in the process, and by cooling, a fresh portion of muriat of barytes will crystallize.

The composition of some of the sulphats is thus given by Berzelius.[c]

Sulphat of Barytes is thus found: 100 parts of carbonat of barytes contain 77.904 barytes, and produce 118.6 sulphat of barytes. Hence the composition of this latter salt is

Sulphuric acid	34.314	—	100.000
Barytes . .	65.686	—	191.427

Sulphat of Potash. 100 parts of ignited sulphat of potash give 134.68 of sulphat of barytes, hence it consists of

Sulphuric acid	46.214	—	100.000
Potash . .	53.786	—	116.385

Sulphat of potash when crystallized contains no more than about 1. of water in 300 of the salt.

Sulphat of Soda. 100 parts of ignited sulphat of soda give 164 sulphat of barytes, hence it consists of

Sulphuric acid	56.275	—	100.000
Soda . . .	43.725	—	77.699

Sulphat of Magnesia. 100 parts of ignited sulphat of magnesia give 194.3 of sulphat of barytes; hence this salt consists of

Sulphuric acid	66.64	—	100.00
Magnesia . .	33.36	—	50.06

Sulphat of Ammonia. This salt was analyzed by distillation with lime, and gave 53.1 of sulphuric acid, 22.6 of ammonia, and 24.3 of water of crystallization. Hence (excluding the water) this salt consists of

Sulphuric acid	70.14	—	100.000
Ammonia . .	29.86	—	42.617

SULPHURETS. *Metallic.*

M. Vauquelin has given the results of some experiments, to determine the proportions of sulphur which several metals absorb by fusion. These proportions have been variously stated by different chemists, chiefly owing to a difference in the heat employed, and the mode of its application. In these experiments M. Vauquelin states, that the heat was kept up to a degree sufficient to melt the compounds, and long enough to expell all the superabundant sulphur. The contact of the external air was also avoided. Each experiment was repeated three or four times, and those results were rejected which differed from the majority by more than two hundredth parts. The metals were divided as much as possible, and mixed with thrice their weight of sulphur, and also covered with a layer of sulphur. The sulphurets that required considerable heat for fusion, such as those of iron and copper, were three times successively pulverized and treated with fresh sulphur, to ensure a perfect saturation.

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[a] Phil. Trans. 1810. p. 94.

[b] Phil. Journ. vol. ii. p. 161.

[c] Ann. Chim.

The following are the results:

Sulphuret of Copper.

Copper	-	78.69
Sulphur	-	21.31
		100.00

Sulphuret of Tin.

Tin	-	85.9
Sulphur	-	14.1
		100.0

Sulphuret of Lead.

Lead	-	86.23
Sulphur	-	13.77
		100.00

Sulphuret of Silver.

Silver	-	87.27
Sulphur	-	12.73
		100.00

Sulphuret of Iron.

Iron	-	78.
Sulphur	-	22.
		100.

Sulphuret of Antimony.

Antimony	-	75.
Sulphur	-	25.
		100.

Sulphuret of Bismuth.

Bismuth	-	68.25
Sulphur	-	31.75
		100.00

Sulphuret of Manganese.

Manganese	-	74.5
Sulphur	-	25.5
		100.0

Sulphuret of Arsenic.

Arsenic	-	57
Sulphur	-	43
		100

The sulphuret of manganese is the only one of these combinations which was not made directly from the metal, but instead of it, the dry carbonat of manganese was employed, which, after fusion with sulphur, gave a green spongy mass resembling the native sulphuret, and gave abundance of sulphuretted hydrogen by dilute nitric acid. M. Vauquelin reckons the quantity of sulphur in this sulphuret to be at least equal to the loss of weight which the dry carbonat would undergo by ignition *per se;* in which case the manganese in this sulphuret will be in the state of sub-oxyd. If, however, it passes to the reguline state by fusion with sulphur, the proportion of the latter substance must be greater than is here stated, by the weight of the oxygen supposed to remain.

Most of these proportions here given agree pretty nearly with those of Proust, and also of Berzelius, with the exception of iron. M. Vauquelin accounts for the difference between his and Proust's estimation of the sulphur in the sulphuret of iron, by the different circumstances of the respective experiments, the latter chemist having employed a much lower temperature. But the artificial sulphurets of iron prepared by Proust, agree very nearly in composition with the two natural sulphurets analyzed by Mr. Hatchett, viz. the magnetical, and the common pyrites, as we have fully related in the *Chem. Dict.* Art. *Iron.* These apparent inaccuracies are readily reconciled, by supposing each of these sulphurets to exist in definite proportions, that of Vauquelin being in the lowest known degree of sulphuration. This will also account for the intermediate sulphuret, between the magnetical and the common pyrites, actually obtained by Mr. Hatchett, by distilling the magnetical pyrites with sulphur in a low red-heat short of fusion, the existence of which is assumed hypothetically by Berzelius, as the base of the red sulphat of iron.

The four sulphurets of iron thus obtained, will therefore be composed as follows, taking M. Vauquelin's experiment as the basis of the calculation, and encreasing the sulphur in this sulphuret by the simple ratios of 2, 3, and 4 times 28.21.

First Sulphuret (artificial).

Iron	78	—	100.00
Sulphur	22	—	28.21

Second Sulphuret (natural)
Magnetical Pyrites.

Iron	63.93 —	100.00
Sulphur	36.07 —	56.42

Third Sulphuret (artificial).

Iron	54.16 —	100.00
Sulphur	45.84 —	84.63

Fourth Sulphuret (natural)
Common Pyrites.

Iron	46.98 —	100.00
Sulphur	53.02 —	112.84

See Article Affinity and Iron, *in this Appendix.*

T

TABULAR SPAR.

The colour of this mineral is greyish white, passing more or less into greenish, yellowish, and redish. Its structure is lamellar in one direction, but on a near examination joints may be observed parallel to the sides of a slightly rhomboidal prism, with further indications of joints parallel to the two diagonals. These lamellæ are often aggregated into coarsely fibrous or prismatic distinct concretions. The lustre of the recent fracture is shining and pearly. It is translucent and moderately hard. Sp. gr. 2.86. When scratched by a point of iron in the dark it becomes phosphorescent. When thrown into nitric acid it makes a momentary effervescence and then divides into grains. It is composed, according to Klaproth, of

50.	Silex
45.	Lime
5.	Water
100.	

It has been found only at Dognatska in the Bannat, where it occurs in a vein mixed with bluish lamellar calcareous spar with green garnets.

TOPAZ.

The mineral described by Werner under the name of Schorlaceous Beryl, and by Haüy under that of Pycnite, has recently been discovered to bear a very striking analogy to topaz. Its characters in brief are the following. Hardness, somewhat superior to that of quartz; colour, yellowish, greenish and redish-white, more or less translucent. It occurs either massive composed of parallel prismatic concretions with transverse rents, or crystallized in long hexahedral prisms. Cross fracture imperfectly foliated; longitudinal fracture imperfectly conchoidal, with a glistening resinous lustre: fragile. Sp. gr. 3.5

Not electric by heat; infusible before the blowpipe. Has been analyzed by Klaproth and Vauquelin with the following results.

K.		V.	
43.	—	30.	Silex
49.5	—	60.	Alumine
0.	—	2.	Lime
4.	—	6.	Fluoric acid
1.	—	1.	Water
1.	—	0.	Oxyd of iron
98.5		99.	

It occurs in Saxony, Bohemia, and Moravia, imbedded in gneiss, or in a rock composed of quartz and mica.

U

ULMIN.

This name has been given by Dr. Thomson, to a peculiar gum-like matter, found occasionally on the trunk of the elm tree, which was first obscurely noticed by Vauquelin, as contained in a morbid juice flowing from the tree;[a] and afterwards more fully analyzed by Klaproth,[b] as composing a solid matter sent to this eminent chemist from Palermo. A substance almost exactly similar, collected from an elm-tree at Plymouth, has since been analyzed by Dr. Thomson;[c] and still more recently, a portion of the same sample that was examined by Klaproth, has been analyzed by Mr. Smithson.[d] All these so nearly agree in their results, that the same description will serve for all.

Ulmin is a bright, hard, black substance, breaking with a vitreous fracture. It is nearly tasteless. When heated it does not melt, but swells very much. It readily burns at the flame of a candle, or in an open crucible, and leaves a white alkaline ash, consisting chiefly of subcarbonat of potash, of which the potash alone, according to Mr. Smithson, is about a fifth of the weight of the ulmin employed. Notwithstanding this great proportion of alkali, the solution of ulmin itself shews little if any traces of free alkali by its effects on vegetable colours, so that the alkali must be under some form of combination which masks its peculiar characters, though the nature of this combination is unknown. In this respect however it agrees with all other vegetable matter, yielding an alkaline ash; but what is remarkable is the ready formation of nitrat or muriat of potash, by adding these acids to the watery solution of ulmin. Ulmin dissolves readily and copiously in water, and the solution, when evaporated to dryness, is equally again soluble in water. But neither alcohol nor ether have any action on ulmin, and in this respect it differs from vegetable extract, which readily dissolves in alcohol. The watery solution of ulmin is not disturbed by solution of isinglass, by tincture of galls, or by prussiat of potash. Green sulphat of iron gives a copious muddy brown precipitate. The same effect is produced by muriat of tin, nitrat of mercury, and superacetate of lead. Common spirit of wine does not disturb the watery solution, but pure alcohol separates the ulmin almost totally, according to Klaproth.

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[a] Ann. Chim. tom. 21,

[b] Thomson's Annals, No. 1.

[c] Ibid.

[d] Phil. Trans. 1813.

Another remarkable character of ulmin is this: when nitric or muriatic acid is poured into the watery solution, a copious precipitate, resembling a resin, falls down, and the liquor affords, on evaporation, nitrat or muriat of potash, according to the acid used, as already mentioned. This resin-like substance differs from the entire ulmin in being soluble in alcohol as well as in water, but in each sparingly. The solution in water is much helped by the addition of alkali, and the liquor then closely resembles the original ulmin.

When nitric acid is added to a watery solution of ulmin, and the resinous matter thence produced is separated by the filter, the remaining liquid, when evaporated, furnishes a yellow matter that deflagrates vividly when heated to from 300° to 400° Fahr. owing to the intimate combination of the nitre, with either a portion of the resin remaining in solution, or with some other combustible matter not separable by this acid. Ulmin is therefore composed, of potash, of a peculiar resin-like or rather extractive matter, and probably of some other vegetable principle which has hitherto not been produced in its separate state.

URINE. Urea. Uric Acid.

The greater part of the extract of healthy urine consists of *Urea*, which is separated (as mentioned under the article *Urine*, *Ch. Dict. vol.* 2.) in the form of light pearly scales like boracic acid, on the addition of a little nitric acid.

But in that singular disease, the diabetes mellitus, the urea diappears more or less completely, and a true saccharine matter takes its place in the extract of urine. It is of some importance to be able to find the relative proportions of urea and saccharine matter at the time when this disease is not fully formed, or when it is giving way to particular modes of treatment.

Dr. Henry has given some experiments on this point,[a] by making artificial mixtures of different proportions of diabetic sugar and extract from healthy urine, and he finds that this separation of scaly crystals of urea, on adding nitric acid, does not appear even after standing many hours, where the sugar is six times the quantity of the extract.

But though the urea under these circumstances, cannot be obtained in a separate state, its existence may be proved, and even its proportion estimated, with tolerable accuracy, by the quantity of carbonat of ammonia which the extract of urine will yield when distilled by a boiling-water heat; for Messrs. Fourcroy and Vauquelin have shewn, that urea is the only animal matter hitherto known, which can be decomposed and yield ammonia at so low a temperature; and nearly the whole of this alkali, produced from urine, is to be attributed to decomposed urea. Hence it is that manufacturers, who distill urine for the ammonia, find that fresh urine yields as much of this alkali as when putrid.

Uric Acid. A memoir has been published on this acid by Dr. Henry,[b] who has given a full account of its distinguishing properties and its saline compounds. Dr. H. obtained it from that species of urinary calculus which is composed chiefly of this acid. To obtain it, let the calculus, finely powdered, be dissolved in a heated solution of pure potash, supersaturate the liquid with muriatic acid, and the uric acid will fall down in white shining plates, which must be repeatedly washed with distilled water with a little carbonat of ammonia added to the first washings, and dried at a heat not exceeding boiling water. This acid will redden litmus, but has no sour taste. It unites with the pure alkalies and saturates them, but will not expell the carbonic acid from the carbonated alkalies. When a little of this uric acid is heated on a bit of glass, with a few drops of nitric acid, and evaporated to dryness, the residuum has a beautiful red colour, which stains animal and vegetable matter. This colour is destroyed by acids and pure alkalies, and is not restored by any known re-agent. This singular property of reddening when heated with nitric acid, is quite characteristic of *Uric Acid*, but, as the author asserts, does not belong to *Urea*. The uric acid, when digested in substance with a solution of soap, is more copiously dissolved than it could be in water alone, and in this degree of concentration it decomposes the soap, separating part of the oil, and forming a kind of emulsion with the rest and the alkali.

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[a] Medico-Chirurgical Trans. vol. 2.

[b] Manchester Trans. vol. 2. second series.

Caustic potash copiously dissolves uric acid, but this solution is decomposed by all acids, even the carbonic, and by carbonat of ammonia. Where less acid is used than will saturate all the alkali, an insoluble urat of potash falls down, but where an excess of the precipitating acid is used, the uric acid separates singly. The urats are all insipid and little soluble.

W

WAVELLITE.[a] Hydrargillite.

This substance occurs in fibres or acicular four-sided prisms, sometimes aggregated into stalactitical masses, but more usually diverging from a common centre, and either separated or adhering to each other by their sides, composing hemispherical concretions of various sizes up to the bulk of a small hazel-nut. The colour is greyish greenish or yellowish white, and often superficially an ochery brown. Its lustre is silky; it is more or less translucent, and is harder than calcareous spar. Sp. gr. about 2.7.

It is infusible *per se*, but by a strong heat becomes white and opake. It is readily melted by the assistance of borax.

By an intense heat it gives out nearly 30 per cent. of a somewhat empyreumatic and slightly acidulous water. It is composed, according to Sir H. Davy, of

70.	Alumine
1.4	Lime
26.2	Water
97.6	
2.4	loss

Subsequent examination has since detected in it a portion of fluoric acid.

It was first discovered by Dr. Wavel, lining the joints and forming veins in a soft argillaceous slate near Barnstaple in Devonshire: it was next found by Mr. Gregor, adhering to quartz crystals, and resembling zeolite, in a mine called Stenna Gwyn in Cornwall. It has also since been discovered in Ireland near the town of Cork; and the stalactitical variety has been brought from Brazil by Mr. Mawe.

WINE. See ALCOHOL.

Z

ZINC.

It has been mentioned in our former article that zinc, though but imperfectly malleable when cold, is very compleatly so when heated from 210° to 300°, so as to allow of its being beaten out or laminated into very thin plates and drawn out into fine wire. It appears too that the zinc after having been thus wrought, does not return to its former brittleness; and hence it may be employed with equal ease as lead or copper for plating, sheathing, roofing, &c. Laminated zinc does not readily rust in the air beyond the first thin hard coating of oxyd, which protects the metal beneath from the further action of the air. This mode of rendering zinc malleable was first employed in this country by Messrs. Hobson and Silvester of Sheffield.

Oxydation of Zinc. It is not well ascertained whether there is more than one oxyd of zinc, which is the white flocculent oxyd that rises from the combustion of this metal; and is also the same that enters into the composition of all the salts of this metal. Proust gives the composition of this oxyd to be 80 of metal and 20 of oxygen. Berzelius[b] found that 10 parts of distilled zinc dissolved in nitric acid and the solution evaporated and ignited, encreased to

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[a] Phil. Trans. 1805.

[b] An. Chim. tom. 81. p. 24.

12.44, which therefore gives for the composition of the oxyd

Zinc .	80.39	—	100.0
Oxygen	19.61	—	24.4
	100.00		124.4

This agrees very nearly with Proust.

When zinc is burned in chlorine (oxymuriatic gas) a gray solid semitransparent substance is formed, usually called *butter of zinc*, (*zincane* of Davy).[c] It is also produced by heating together zinc filings and corrosive sublimate. This has a waxy consistence, fuses at about 212°. and is sublimed at less than a red heat. It is composed of equal parts by weight of zinc and chlorine.

Zinc readily alloys with potassium and sodium.

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[c] Elements.

ADDENDUM.

IODINE.

A new and very singular substance has lately been discovered in France by M. Courtois, and a general sketch of its properties has been given in the Moniteur for the 12th of December last. A translation of this paper, with some facts relative to the preparation of this substance by Dr. Thomson, is inserted in No. 14 of the Annals of Philosophy, from which this account is chiefly extracted.

The substance in question, *Iodine*, is prepared from kelp by a very simple process. The kelp is lixiviated with water, and the solution evaporated to dryness. This dry salt is put into a tubulated retort, with a short neck fitting into a large globular glass receiver, leaving room for the air to escape: strong sulphuric acid is poured on the salt through the tubulure of the retort, a violent effervesence ensues, and a violet coloured gas is driven off in abundance, which condenses on the receiver into shining crystallized spiculæ of a metallic appearance, somewhat resembling very fine plumbago. This substance is *Iodine*, so called from the *violet* colour (ιωδης) which it assumes when in vapour, and may be washed out of the receiver with water.

Instead of using the entire saline contents of kelp, the solution may be boiled down and crystallized, and the mother water of these first crystals, separately evaporated to dryness, will yield the iodine more abundantly than the whole salt. Neither the first crystals of the solution of kelp, nor the residue insoluble in water, will afford any iodine.

Iodine is an opake shining solid, permanent at a moderate temperature. When heated to about the temperature of boiling water it totally evaporates, forming a beautiful violet coloured vapour, which immediately again condenses unchanged on the cooler part of the vessel.

The chemical properties of iodine hitherto discovered are very curious. It possesses in a high degree the electrical properties of oxygen and oxymuriatic acid, and when combined with hydrogen it forms a peculiar *acid* very soluble in water, capable of assuming the gaseous form, and bearing the same relation to iodine that muriatic acid does to chlorine. The action of the different reagents on iodine will be the easiest understood by the reader by bearing this relation in mind.

When dry iodine and phosphorus are placed in contact, a reddish-brown substance is produced, and no gas is given out. When just moistened, copious acid fumes appear, which form a permanently elastic acid gas. The same acid is produced in liquid solution when the phosphorus and iodine are combined under water. In either case phosphoreous acid is generated, together with the peculiar acid of iodine. If the iodine much exceeds the phosphorus, a red insoluble compound of the two is produced, but when the proportions are properly adjusted, the whole resolves into a limpid acid liquid, containing only phosphoreous acid and the acid of iodine dissolved in water. These may be separated by distillation. The first liquor that condenses is mere water, but when the contents of the retort become very concentrated, the acid of iodine distills over, and at last only phosphoreous acid remains, which gives out abundance of phosphuretted hydrogen.

This may be explained on Sir H. Davy's theory, by supposing that dry phosphorus and iodine simply combine into a compound analogous to that of phosphorus and chlorine; but when water is present it is decomposed, its oxygen acidifying the phosphorus, and its hydrogen acidifying the iodine in the same way as hydrogen is supposed to convert chlorine into muriatic acid.

The acid of iodine when gasseous is without colour, has nearly the smell of muriatic acid, smokes when exposed to the air, is rapidly absorbed by water, and gives a beautiful purple vapour with oxymuriatic gas. This acid gas when shaken with mercury is speedily and totally decomposed, a greenish-yellow substance similar to the compound of iodine and mercury is formed, and hydrogen is evolved equal in volume to half the acid gas.

Iron and zinc produce a similar effect.

The liquid acid of iodine obtained by dissolving the gas in water is a dense fluid, not very volatile, which rapidly decomposes the alkaline carbonates, dissolves iron and zinc with disengagement of hydrogen, but does not attack mercury even when heated, forms a soluble salt with barytes, and a red precipitate with corrosive sublimate. Heated with the black oxyd of manganese, with minium, or with the brown oxyd of lead, it so far reduces these oxyds as to bring them to a state of solubility in acids, and iodine is disengaged. This partial reduction of the oxyds and total reduction of the acid of iodine appears therefore to be owing to the transfer of the hydrogen of the latter acid to the metallic peroxyd and consequent production of an equivalent portion of water. The red oxyd of mercury however does not regenerate iodine. When this acid is dissolved in water and exposed to galvanic action, iodine appears at the positive pole. The acid of iodine is not readily expelled from its compounds in its acid state. Thus when sulphuric acid is added to the salt formed by acid of iodine and potash, iodine alone is disengaged, and sulphureous acid unites with the alkali.

Sulphuretted hydrogen speedily deprives iodine of its colour, converts it to acid of iodine, and sulphur is deposited.

Iodine does not decompose water at any temperature. It combines with most metals without disengaging any gas. It dissolves in about a fifth of its weight of zinc. When this compound is heated under water nothing is disengaged, but a limpid solution is gradually formed, from which the alkalies separate an oxyd of zinc. Part of the water therefore appears to have been decomposed, its hydrogen acidifying the iodine, and its oxygen oxydating the zinc.

All these phenomena may be explained, as Dr. T. observes, either by supposing iodine to be an element and to form an acid by combining with hydrogen: or by supposing the acid of iodine to be a compound of water and an unknown base, and iodine to be this base united to oxygen.

FINIS.

London:
Printed by W. Phillips, George Yard, Lombard Street.

APPENDIX, No. II.

CONTAINING

TABLES OF WEIGHTS AND MEASURES—English and Foreign;

OF CHEMICAL INSTRUMENTS;

OF THE COMPOSITION OF ACIDS AND SALTS;

AND OF CHEMICAL AFFINITIES.

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APPENDIX, No. II.

OF ENGLISH WEIGHTS AND MEASURES.

THE weights and meaſures required by the chemiſt are few and ſimple, but they ſhould be accurate, and their relative values well defined.

For the meaſure of weight, the Troy pound of 12 ounces, or 5760 grains, is the integer almoſt always preferred, being that which admits of a minuter ſubdiviſion, and whoſe correſpondences with meaſures of capacity are more accurately defined; though there are ſtill ſome ſlight differences in this reſpect which it were to be wiſhed were removed by authority. The ſubdiviſions of the Troy ounce employed by chemiſts are ſometimes thoſe of Apothecaries weight, that is, the ounce into 8 drams, the dram into 3 ſcruples, and the ſcruple into 20 grains, or more commonly, ſimply into drams and grains; or ſometimes the ounce is divided into 20 pennyweights, and the pennyweight into 24 grains. Often the grain is the only integer employed, and ſets of weights are uſed of the different hundreds, tens, and units. The averdupois pound is however ſometimes adopted, being the ſtandard of moſt things bought and ſold in common life. It is equal to 7000 grains Troy, and is divided into 16 ounces, and the ounce legally into 16 drams, but the latter diviſion is never uſed by chemiſts, being liable to be miſtaken for the Troy dram, which weighs more than twice as much.

For meaſures of capacity, chemiſts employ both the *ounce meaſure* (or bulk occupied by the ounce, or any proportion of it, of diſtilled water at 60°) and the *cubic inch*. For larger quantities both the *Wine Pint* of 28,875 cubic inches, and the *Ale Pint*, of 35.25 cubic inches are uſed. Two pints make a *Quart*, and four quarts make a *Gallon*.

The correſpondence between meaſures of weight and capacity is found by the weight of a cubic inch of water. In this however a ſlight difference exiſts, in authorities apparently equally worthy of confidence, which depends partly on the extreme difficulty of conſtructing inſtruments of perfect accuracy, and partly on ſome ſlight diſcrepancy between the ſtandards themſelves. The extent of this difference is about half a grain in 253. We have adopted in the following Tables the eſtimations given by Sir G. Shuckburgh Evelyn, in the 88th vol. of the Philoſophical Tranſactions, corrected in a ſubſequent paper by Mr. Fletcher, in the 4th vol. of the Philoſophical Journal. On this calculation the cubic inch of diſtilled water at 60°. therm. and 29.5 bar. weighs 252.506 grains Troy.

Hence we have the following equations.

Cubic inch.
1 ounce Troy of water at 60° occupies - - - - - 1.900945

grs. Troy. · *lb. Troy.* · *lb. Averdu.*
1 Wine pint of water weighs - - - 7291.11075 = 1.26581783 = 1.04158725

grs. Troy. · *lb. Troy.* · *lb. Averdu.*
1 Ale Pint of water weighs - - - 8900.8365 = 1.545284 = 1.271548

Wine pint. · *Ale pint.*
1 lb. Troy of water occupies - - - .7900031 = .6471302

Wine pint. · *Ale pint.*
1 lb. Averdupois of water occupies - .960073 = .7864429

We may here notice the very common error of eſtimating a wine pint of water to be equal to 16 ounces Troy, ſince it wants as much as 389 grs. of 16 ounces; when the cubic inch is eſtimated at 252.506 grs. and 375 grs. when the cubic inch is reckoned at 253 grs. which is the higheſt eſtimation. Nevertheleſs as ſeveral meaſuring veſſels are thus graduated, and as the adoption of this ſtandard would be extremely convenient, this meaſurement may be often uſefully employed for moderate quantities; but the chemiſt ſhould then expreſs that he uſes the pint of 16 ounces Troy.

TABLE

For converting Cubic Inches of Water (at 60 Therm. and 29.5. Bar.) into their equivalents in Troy weight.

Cub. Inch of Water		*Troy grs.*		*oz.*		*dram*		*grs.*
1.	weighs	252.506	=	0	:	4	:	12.506
2.		505.012	=	1	:	0	:	25.012
3.		757.518	=	1	:	4	:	37.518
4.		1010.024	=	2	:	0	:	50.024
5.		1262.530	=	2	:	5	:	2.530
6.		1515.036	=	3	:	1	:	15.036
7.		1767.542	=	3	:	5	:	27.542
8.		2020.048	=	4	:	1	:	40.048
9.		2272.554	=	4	:	5	:	52.554
1728.	(1 cub. foot)	———		909	:	0	:	10.368

TABLE

For converting Troy grains, drams, ounces, and pounds of Water into their equivalent Cubic Inches.

Grain		*Cubic Inch*	*Dram*		*Cubic Inch*
1.	=	.00396	1.	=	.237618
2.	=	.00792	2.	=	.475236
3.	=	.01188	3.	=	.712854
4.	=	.01584	4.	=	.950472
5.	=	.01980	5.	=	1.188090
6.	=	.02376	6.	=	1.425708
7.	=	.02772	7.	=	1.663326
8.	=	.03168			
9.	=	.03564			

Ounce		*Cubic Inch*	*Pound*		*Cubic Inch*
1.	=	1.900945	1	=	22.81134
2.	=	3.801890	2	=	45.62268
3.	=	5.702835	3	=	68.43402
4.	=	7.603780	4	=	91.24536
5.	=	9.504725	5	=	114.05670
6.	=	11.405670	6	=	136.86804
7.	=	13.306615	7	=	159.67938
8.	=	15.207560	8	=	182.49072
9.	=	17.108505	9	=	205.30206
10.	=	19.009450			
11.	=	20.910395			

TABLE

For converting Wine Pints of Water into their equivalent Troy and Averdupois Pounds.

Wine Pints	*lbs. Troy*	*lbs.*	*oz.*	*dr.*	*grs.*	*lbs. averdup.*
1. =	1.26581783 =	1 :	3 :	1 :	31.1 =	1.04158725
2. =	2.53163566 =	2 :	6 :	3 :	2.2 =	2.08317450
3. =	3.79745349 =	3 :	9 :	4 :	33.3 =	3.12476175
4. =	5.06327132 =	5 :	0 :	6 :	4.4 =	4.16634900
5. =	6.32908915 =	6 :	3 :	7 :	35.5 =	5.20793625
6. =	7.59490698 =	7 :	7 :	1 :	6.6 =	6.24952350
7. =	8.86072481 =	8 :	10 :	2 :	37.7 =	7.29111075
8. =	10.12654264 =	10 :	1 :	4 :	8.8 =	8.33269800
9. =	11.39236047 =	11 :	4 :	5 :	39.9 =	9.37428525

TABLE

For converting Troy Pounds of Water into their equivalent Wine Pints.

Troy Pound	*Wine Pints*	*Troy Pound*	*Wine Pints*
1. =	0.7900031	6. =	4.7400186
2. =	1.5800062	7. =	5.5300217
3. =	2.3700093	8. =	6.3200248
4. =	3.1600124	9. =	7.1100279
5. =	3.9500155		

TABLE

For converting Troy Pounds into their equivalent Averdupois Pounds.

lbs. Troy	*lbs. Averdups.*	*lbs. Troy*	*lbs. Averdups.*
1. =	$0.82\dot{2}8571\dot{4}$	6. =	$4.93\dot{7}1428\dot{5}$
2. =	$1.64\dot{5}7142\dot{8}$	7. =	5.76000000
3. =	$2.46\dot{8}5714\dot{2}$	8. =	$6.58\dot{2}8571\dot{4}$
4. =	$3.29\dot{1}4285\dot{7}$	9. =	$7.40\dot{5}7142\dot{8}$
5. =	$4.11\dot{4}2857\dot{1}$		

TABLE

For converting Averdupois Pounds into their equivalent Troy Pounds.

lbs. Averd.	*lbs. Troy*	*lbs. Averd.*	*lbs. Troy*
1. =	$1.21527\dot{7}$	6. =	7.291666
2. =	$2.43055\dot{5}$	7. =	$8.50694\dot{4}$
3. =	$3.64583\dot{3}$	8. =	$9.72222\dot{2}$
4. =	$4.86111\dot{1}$	9. =	10.937500
5. =	$6.07638\dot{8}$		

TABLE

For converting Averdupois Ounces into Decimals of the Averdupois Pound.

Oz. Av.	*lbs. Av.*	*Oz. Av.*	*lbs. Av.*
.25 =	.015625	8.00 =	.5000
.50 =	.03125	9.00 =	.5625
1.00 =	.0625	10.00 =	.6250
2.00 =	.1250	11.00 =	.6875
3.00 =	.1875	12.00 =	.7500
4.00 =	.2500	13.00 =	.8125
5.00 =	.3125	14.00 =	.8750
6.00 =	.3750	15.00 =	.9375
7.00 =	.4375		

TABLE

For converting Decimals of the Averdupois Pound into Averdupois Ounces and Decimals.

lbs.Av.	*oz.Av.*	*lbs.Av.*	*oz.Av.*
.1 =	1.6	.01	.16
.2 =	3.2	.02	.32
.3 =	4.8	.03	.48
.4 =	6.4	.04	.64
.5 =	8.0	.05	.80
.6 =	9.6	.06	.96
.7 =	11.2	.07	1.12
.8 =	12.8	.08	1.28
.9 =	14.4	0.9	1.44

TABLE

For converting Ounces, Drams and Grains Troy into Decimals of the Troy Pound.

Grain	*lbs. Troy*	*Dram*	*lbs. Troy*	*Oz.*	*lbs. Troy*
1. =	.00017361$\dot{1}$	1. =	.010416$\dot{6}$	1. =	.083$\dot{3}$
2. =	.00034722$\dot{2}$	2. =	.020833$\dot{3}$	2. =	.166$\dot{6}$
3. =	.00052083$\dot{3}$	3. =	0312500	3 =	.2500
4. =	.00069444$\dot{4}$	4. =	.041666$\dot{6}$	4 =	.333$\dot{3}$
5. =	.00086805$\dot{5}$	5. =	.052083$\dot{3}$	5 =	.416$\dot{6}$
6. =	.00104166$\dot{6}$	6. =	.0625000	6 =	.5000
7. =	.00121527$\dot{7}$	7. =	.072916$\dot{6}$	7 =	.583$\dot{3}$
8. =	.00138888$\dot{8}$			8 =	.666$\dot{6}$
9. =	.001562500			9 =	.7500
				10 =	.833$\dot{3}$
				11 =	.916$\dot{6}$

TABLE

For converting Decimals of the Troy pound into Troy Ounces, Drams, and Grains.

lb.		oz.	dr.	grains	lb.		oz.	dr.	grains	lbs.		grains.
.1	=	1	1	36	.01	=	0	0	57.6	.001	=	5.76
.2	=	2	3	12	.02	=	0	1	55.2	.002	=	11.32
.3	=	3	4	48	.03	=	0	2	52.8	.003	=	17.28
.4	=	4	6	24	.04	=	0	3	50.4	.004	=	23.04
.5	=	6	0	0	.05	=	0	4	48.0	.005	=	28.80
.6	=	7	1	36	.06	=	0	5	45.6	.006	=	34.56
.7	=	8	3	12	.07	=	0	6	43.2	.007	=	40.32
.8		9	4	48	.08	=	0	7	40.8	.008	=	46.08
.9		10	6	24	.09	=	0	8	38.4	.009	=	51.84

FRENCH WEIGHTS AND MEASURES.

THE numerous and valuable reſearches of French authors in every branch of chemiſtry require a knowledge in the reader of the weights and meaſures commonly employed by them; which is more particularly neceſſary as the denominations common to ſeveral meaſures in both countries expreſs very different quantities both abſolutely and relatively, which ſometimes leads to very ſerious miſtakes. Thus the French *pinte* is equal to nearly two Engliſh pints: the *gros* or eighth of an ounce contains 72 grains, whereas our *dram*, which is uſually reckoned as its equivalent, contains only 60 grains: the French grain is of leſs abſolute weight than the Engliſh grain, but the French inch is longer, and hence the ſame proportion does not hold in the two countries between the meaſures of weight and capacity.

The ſtandards of weight and meaſure were totally changed in France about the year 1794, nearly at the time that ſimilar changes were introduced in the diviſions of the year, but though the notation of time has now returned to its ancient courſe, the ſyſtem of weights and meaſures appear ſtill to keep their ground, and are actually adopted in all chemical writings. It is highly neceſſary, however, to give the old, as well as the new ſyſtem of menſuration, as the moſt numerous, and as yet the moſt important, reſearches, ſuch as thoſe of Lavoiſier, Beaumé, Macquer, &c. were made before the preſent ſyſtem was adopted.

We poſſeſs very accurate ſtandards of compariſon between the French weights and meaſures and our own, the old French having been carefully compared with the Engliſh ſtandards by a commiſſion from the Royal Societies of each country in the year 1752; and the modern French *metre* having been compared with equal accuracy with the Engliſh inch by Profr. Pictet in 1801.

The old French weights and meaſures are the following:

The pound (*poids de marc*) contains 9216 grains, and is divided into 16 ounces, the ounce into 8 gros, and the gros into 72 grains: or as follows:

grains
24 = 1 denier
72 = 3 = 1 gros
576 = 24 = 8 = 1 ounce
4608 = 192 = 64 = 8 = 1 marc
9216 = 384 = 128 = 16 = 2 = pound

The French pound is equal to	7561.	troy grains	=	*lb. troy* 1.31268
The French ounce is =	472.5625	d°	=	*oz. troy* .984504
The French gros =	59.0703125	d°	=	*dram* .984504
The French grain =	0.820421	d°		
The troy pound is equal to	7021.	French grains		
The averdupois pound =	8538.	d°		

In the reduction of the French into Engliſh meaſure, the following Table will aſſiſt.

French grains		*Troy grains*
1.	=	0.820421
2.	=	1.640842
3.	=	2.461263
4.	=	3.281684
5.	=	4.102105
6.	=	4·922526
7.	=	5·742947
8.	=	6.563368
9.	=	7·383789
10.	=	8.20421
20.	=	16.40842
30.	=	24.61263
40.	=	32.81684
50.	=	41.02105
60.	=	49.22526
70.	=	57·42947
72.	=	59.070312

gros		*drams*		*grs.*
1	=	0	:	59.07
2	=	1	:	58.14
3	=	2	:	57.21
4	=	3	:	56.28
5	=	4	:	55·35
6	=	5	:	54.42
7	=	6	:	53·49

French oz.		*Troy oz.*		*drams*		*grains*
1.	=	0	:	7	:	52.56
2.	=	1	:	7	:	45.12
3.	=	2	:	7	:	37.68
4.	=	3	:	7	:	30.24
5.	=	4	:	7	:	22.80
6.	=	5	:	7	:	15.36
7.	=	6	:	7	:	7.92
8.	=	7	:	7	:	0.48
9.	=	8	:	6	:	53.04
10.	=	9	:	6	:	45.60
11.	=	10	:	6	:	38.16
12.	=	11	:	6	:	30.72
13.	=	12	:	6	:	23.28
14.	=	13	:	6	:	15.84
15.	=	14	:	6	:	8.40
Pounds						
1.	=	15	:	6	:	1
2.	=	31	:	4	:	2
3.	=	47	:	2	:	3
4.	=	63	:	0	:	4
5.	=	78	:	6	:	5
6.	=	94	:	4	:	6
7.	=	110	:	2	:	7
8.	=	126	:	0	:	8
9.	=	141	:	6	:	9

The French toiſe (which correſponds with our fathom) contains 6 feet, the foot is divided into 12 inches, and the inch into 12 lines.

The French half-toiſe was found by the authentic meaſurement of the French academy to be equal to 38.355 Engliſh inches; and hence

The French foot is equal to 12.785 Engliſh inches, or to *Engliſh foot* 1.0654167

The Engliſh foot = 11.2632 French inches, or to *French foot* .9386

The ſub-diviſions of the foot being the ſame in both countries, their relative proportions are alſo the ſame; ſo that the French inch = 1.0654167 Engliſh inches;—and the Engliſh inch = .9386 French inches.

The old French ell (*Aune*) = *feet* 3 : *inch* 7 : *lines* 10.5 French, = *Eng. inches* 46.69

French feet		*Engliſh inches*
1.	=	12.785
2.	=	25.570
3.	=	38.355
4.	=	51.140
5.	=	63.925
6.	=	76.710
7.	=	89.495
8.	=	102.280
9.	=	115.065
10.	=	127.850

Fr. feet or inches		*Eng. feet or inches*
1	=	1.0654+
2	=	2.1308
3	=	3.1962
4	=	4.2616
5	=	5.3270
6	=	6.3925
7	=	7.4579
8	=	8.5233
9	=	9.5887
10	=	10.6541
11	=	11.7195
12	=	12.7850

The French ſquare foot or inch = 1.13510 Engliſh ſquare foot or inch
The Engliſh ſquare foot or inch = .88126 French ſquare foot or inch
The French cubic foot or inch = 1.209367 Engliſh cubic foot or inch
The Engliſh cubic foot or inch = .8268784 French cubic foot or inch

French cube foot or inch		*Eng. cube foot or inch*
1	=	1.2093+
2	=	2.4187
3	=	3.6281
4	=	4.8374
5	=	6.0468
6	=	7.2562
7	=	8.4655
8	=	9.6749
9	=	10.8842
10	=	12.0936

When one French cubic inch weighs 1 grain French, or contains 1 gr. of any other ſubſtance, 1 Engliſh cubic inch of the ſame weighs or contains .67839 Eng. grain.

For meaſures of capacity the old French was (as in this country) different for dry meaſure and for liquids. The common integer for moderate quantities of liquids was the *Pinte*, which is a little more than a quart Engliſh wine meaſure. The *Chopine* is half the *Pinte*, and the *Poiſon* is a quarter of the Chopine. For larger meaſures, 8 *Pintes* make a *Septier* or *Velte* and 36 *Veltes* make a *Muid de Vin* Paris meaſure, for in the provinces both the diviſions and their value were different. There appears alſo to have been, even in Paris, preciſely the ſame kind of variation in the eſtimation of the *Pinte* as obtains in this country with the wine pint. The French *Pinte* appears to have been legally equivalent to 48 Fr. cubic inches, and then was exactly $\frac{1}{288}$ of the *Muid*, which was 8 cubic feet. But Beaumé, and probably the other apothecaries of Paris (a body of men abounding in excellent and eminent chemiſts) make the *Pinte* equal to 32 French ounces of water at the freezing point. The reſpective valuations of the Pinte will therefore be as follows:

oz. — *lbs. troy* — *En. cub. inch* — *Fr. cub. in.* — *Eng. wine pint*
The pinte of 32 = 2.62536 = 59.888 = 49.52 = 2.07404

cub. inch — *Eng. cub. inch*
The pinte of 48 = 58.0489 = . . . 2.01035

difference .06369, equal to
about 7 drams, 40 grs. Troy of water.

This difference of nearly an ounce in a quart is ſufficiently great to be often felt in the compariſon of experiments. The Pinte of 48 Fr. cubic inches appears for another reaſon to be the legal ſtandard, ſince it is thus given in the compariſon of the old with the new French weights. The Pinte is there ſtated to be equal to .9512 of a *Litre*, which is equal to 2.01038 Engliſh wine pints.

For dry meaſure the French uſed the *Litron*, *Boiſſeau*, *Minot*, *Mine*, and *Setier de Bled*. The *Litron* is 36 Fr. cubic inches, equal to 1.4652 Eng. wine pint. The *Minot* of 1728 Fr. cub. inch is equal to 1.0099 Wincheſter buſhel of 2110.4 Eng. cub. inch.

The following are the ſubdiviſions of the old French wine and corn meaſure.

Poiſon
4= 1 Chopine
8= 2= 1 Pinte
64= 16= 8= 1 Septier or velte
2304=576=288= 36=1 Muid de vin

Litron
4= 1 Quart
16= 4= 1 Boiſſeau
48=12= 3=1 Minot
96=24= 6=2=1 Mine
192=48=12=4=2=1 Setier de Bled

A totally new ſyſtem of weights and meaſures has been introduced into the French empire, and is that in which moſt of the expreſſions of quantities in chemical experiments are now made. It is therefore neceſſary in this place to give their correſponding quantities in Engliſh meaſures.

The new French metrical ſyſtem is founded on a ſingle ſtandard of length which is called the METRE, and is the ten millionth part of the arc of the meridian which extends from the Equator to the Pole, as determined by the actual meaſurement of a tenth of this arc, between Dunkirk and Barcelona by ſeveral eminent French aſtronomers. The metre is equal to 36.9413 French inches, which is equal to 39.38272 Engliſh inches, the ſtandards of each being at the temperature of melting ice or 32° Fahr. But as the ſtandards in this country are always referred to the temperature of 60° or 62°, (and the latter is now preferred) the expanſion of braſs (which is the material of which the ſtandards are made) from 32° to 62° muſt always be taken into account; for it is obvious that if the Engliſh ſtandard is at 62° and the French at 32°, the latter will meaſure a leſs quantity of the former than if both were at 32°. The number 39.38272 therefore, which is the equivalent to the French metre when both are at 32°, muſt be diminiſhed in the proportion in which braſs expands 30 degrees, which is eſtimated by Dr. Young, from Bordas experiments, to make the equivalent to the metre to be 39.371 Engliſh inches, the ſtandard of the metre being at 32°, and that of the Engliſh inch at 62°.

All the new French meaſures increaſe and decreaſe in decimal proportion, a diſtinctive prefix being put to the term by which the integer is called. Theſe prefixes are Deca-, Hecto-, Kilo-, and Myria-, (taken from the Greek numerals) to expreſs the *multiplication* of the integer by 10, 100, 1000, and 10000 reſpectively; and Deci-, Centi-, and Milli-, (from the Latin numerals) to expreſs the *diviſion* of the integer by 10, 100, or 1000. Or according to the following ſcale, taking the metre as the integer.

		Metres			*Metres*
1 Myriametre	=	10000.	1 Metre	=	1.
1 Kilometre	=	1000.	1 Decimetre	=	0.1
1 Hectometre	=	100.	1 Centimetre	=	0.01
1 Decametre	=	10.	1 Millimetre	=	0.001

The metre is the integer of the meaſure of length, and from it all the meaſures of ſurface, capacity and weight, are deduced in the following way.

For ſquare dimenſions the metre or its parts ſquared are employed. When uſed for meaſuring land the term *Are* is adopted, which is a decametre ſquared. A *Hectare*, or 100 *Ares*, are about equivalent to 2 Engliſh acres.

For the integer of the meaſure of capacity both wet and dry, the decimetre cubed is employed, and is called the *Litre*. It is more than a third larger than the old French Litron, and is equal to $2\frac{1}{8}$ Engliſh wine pints.

The cubic metre is alſo called a *Stere*, but is only uſed for meaſuring fire wood, to be ſubſtituted for the old French *Corde de Bois*.

For the integer of the meaſure of weight, the weight of a cubic centimetre of diſtilled water at 32° has been adopted. This is called a *Gramme*, and is equivalent to about $15\frac{1}{2}$ Engliſh grains.

Of theſe meaſures the *Metre, Litre,* and *Gramme,* are almoſt the only integers that the chemical reader will ever meet with, and certainly their uniformity and exact ratio to each other, and decimal progreſſion, render the compariſon of them with our own meaſures extremely eaſy.

The following are the correſpondences between theſe and Engliſh meaſures.

The METRE = 39.371 Engliſh inches.

The ſquare Metre = 1550.075641 Engliſh ſquare inches.

The ſquare Decimetre = 15.50075 Engliſh ſquare inches.

cube feet. cub. inch.
The Cubic Metre = 61028.028 Engliſh cubic inches = 35 : 548.028.

The Cubic Decimetre, the ſame as the Litre. *Engliſh cubic inches.*
THE LITRE, equal to the bulk of Kilogramme of water = 61.028

Troy grains.
THE GRAMME, or weight of a cubic Centimetre of water = 15.44402.

The following Tables will aſſiſt the Reader.

Metre.		*Eng. feet.*		*Inches.*
1.	=	3	:	3.371
2	=	6	:	6.742
3	=	9	:	10.113
4	=	13	:	1.484
5	=	16	:	4.855
6	=	19	:	8.226
7	=	22	:	11.597
8	=	26	:	2.968
9	=	29	:	6.339

Decimetre.		*Eng. Inches.*
1.	=	3.9371
2.	=	7.8742
3.	=	11.8113
4.	=	15.7484
5.	=	19.6855
6.	=	23.6226
7.	=	27.5597
8.	=	31.4968
9.	=	35.4339

Litre		*En. cub. inch*		*Ale pints*		*Wine pints*		*Oz. troy of water*
1.	=	61.028	=	1.7313	=	2.11353	=	32.104
2.	=	122.056	=	3.4626	=	4.22706	=	64.208
3.	=	183.084	=	5.1939	=	6.34059	=	96.312
4.	=	244.112	=	6.9252	=	8.45412	=	128.416
5.	=	305.140	=	8.6565	=	10.56765	=	160.520
6.	=	366.168	=	10.3878	=	12.68118	=	192.624
7	=	427 196	=	12.1191	=	14.79471	=	224.728
8	=	488.224	=	13.8504	=	16.90824	=	256.832
9	=	549.252	=	15.5817	=	19.02177	=	288.936

Gramme		*Troy grains*
1.	=	15.444
2.	=	30.888
3.	=	46.332
4	=	61.776
5	=	77.220
6	=	92.664
7	=	108.108
8	=	123.552
9	=	138.996

Decagramme		*Troy dram*		*grs.*
1.	=	2	:	34.44
2.	=	5	:	8.88
3.	=	7	:	43.32
4.	=	10	:	17.76
5.	=	12	:	52.20
6.	=	15	:	26.64
7.	=	18	:	1.08
8.	=	20	:	35.52
9.	=	23	:	9.96

Hectogramme		*Troy oz.*		*Averd. oz.*
1.	=	3.2175	=	3.5279
2.	=	6.4350	=	7.0558
3.	=	9.6525	=	10.5837
4.	=	12.8700	=	14.1116
5.	=	16.0875	=	17.6395
6.	=	19.3050	=	21.1674
7.	=	22.5295	=	24.6953
8.	=	25.7400	=	28.2232
9.	=	28.9575	=	31.7511

The decimal progreſſion of all the French weights and meaſures renders it only neceſſary to change the decimal point in order to convert one into the equivalent of any other, of the ſame ſpecies and numerically the ſame, but of a different denomination. Thus as 9 litres are equal to 15.5817 ale pints, 9 hectolitres will be equal to 1558.17 ale pints; and ſo of the reſt.

GERMAN WEIGHTS AND MEASURES.

A VAST variety of weights and meaſures are in local uſe in Germany, as ſlight differences exiſt between the *mark*, *ell*, &c. of almoſt every ſtate. There appears, however, from the accurate account given by Gren (in his Syſtem. Handbuch der Chemie, Vol. 1.) to be two kinds of weight to which all thoſe employed in Germany may be referred, and which are ſufficient for our preſent purpoſe.

The ancient and moſt authentic ſtandard of weight is the

Cologne Mark or *Mark of Charlemagne* with its diviſions. The mark is the higheſt integer uſed in this ſtandard which was intended for gold and ſilver, but it is alſo conſidered as half the Cologne pound. The *mark* contains 8 ounces, the *ounce* 2 loths, the *loth* 4 quentchens or drams, and the *quentchen* 1 pfenning, pennyweight, or denier. Beſides this, the *pfenning* is ſubdivided into 256 *Recht-pfenning theil*, or ſtandard parts, which laſt diviſion, however, is only hypothetical, but is extremely uſeful for compariſon; for as the pfenning is itſelf the 256th part of the mark, the latter contains 65536 ſtandard parts, which is a ſufficiently minute diviſion for all actual calculations. The Cologne Mark therefore is thus divided:

Standard parts
256 = 1 Pfenning
1024 = 4 = 1 Quentchen
4096 = 16 = 4 = 1 Loth
8192 = 32 = 8 = 2 = 1 Ounce
65536 = 256 = 64 = 16 = 8 = 1 Mark

Alſo two marks make a pound. The Pfenning is further ſubdivided either into 2 *Heller*, or into 17 *Eſchen*, or into 9 *As*.

The *Grain* weight therefore does not enter into this diviſion of the Cologne Mark; but in the diviſion for weighing gold and ſilver it is uſed, as will be mentioned.

The other ſet of weights uſed commonly in Germany is the *Nuremburg Medicinal Weight*, the integer or pound of which is divided preciſely the ſame as the apothecaries' diviſion of the Engliſh pound Troy; that is to ſay, the pound into 12 ounces, the ounce into 8 drams, the dram into 3 ſcruples, and the ſcruple into 20 grains. Neither the pound nor ounce nor dram of the Nuremburg weight are the ſame as the pound, ounce, and quentchen of the Cologne weight, the Nuremburg pound being=100423.5 ſtandard parts — and the ounce = 8368.625 St. Pts. For commerce and common uſe the Nuremburg pound is increaſed to 16 ounces=133898 St. Pts.

The Nuremburg medicinal pound of 12 ounces appears to be the ſtandard for apothecaries' weight all over Germany, and therefore is probably that which is more commonly uſed by chemiſts. Hence, when we meet with the term pound, ounce, dram, and grains, in German chemical authors, we may generally conclude that it is the Nuremburg medicinal weight, unleſs otherwiſe ſpecified.

But the Cologne Mark weight is employed univerſally for aſſaying gold and ſilver, and therefore is alſo of very frequent occurrence.

The Engliſh Troy pound is given by Gren as equal to 104688 St. Pts. of the Cologne Mark, whence the Nuremburg pound, ounce, dram, ſcruple or grain = .959266 Engliſh Troy pound, ounce, dram, &c. reſpectively: or by the following table.

Nuremberg		*Eng. troy*	*Nuremberg*		*Eng. troy*
1	=	0.95926	6	=	5.75560
2	=	1.91853	7	=	6.71486
3	=	2.87780	8	=	7.67413
4	=	3.83706	9	=	8.63339
5	=	4.79633			

The Cologne ounce is = 8192 ſtandard pts. and the Troy ounce is = 8724 ſt. pts. whence the Cologne ounce, and eighth of an ounce (or quentchen) is = .939018 Troy ounce or dram reſpectively: and the Cologne mark is = 7.512144 Troy ounces: or by the following table:

Cologne oz. or Quentchen		*Troy oz. or dram*	*Cologne oz. or Quentchen*		*Troy oz. or dram*
1	=	.939	6	=	5.634
2	=	1.878	7	=	6.573
3	=	2.817	8	=	7.512
4	=	3.756	9	=	8.451
5	=	4.695			

When gold and ſilver are weighed in Germany by the Cologne mark, it has a totally different ſubdiviſion from the common ounce, quentchen, and pfenning.

For gold, the mark is divided into 24 carats, and the carats into 12 grains. The *Carat* therefore, where it is a real weight, is equal to 150.242 Troy grains, and the *Grain*, or 288th part of the mark is equal to 12.52 Troy grains.

For ſilver, the mark is divided, as uſual, into 16 *Loths*, or half ounces, but the loth into 18 *Grains*. The grain is in this caſe alſo the 288th part of the mark. This circumſtance of employing the term *grain* occaſionally for a ſubdiviſion of the mark, and giving to it a value upwards of 13 times the Nuremburg grain ſhould be carefully noted, as many errors may ariſe from it, particularly to the Engliſh reader.

The method of conducting the aſſay of gold and ſilver has been deſcribed under the article Assay, and it is there mentioned (p. 117) that the ſmall piece of gold cut off the ingot to be aſſayed is called an *Aſſay mark*, and (like the real mark of gold) is divided into 24 carats, and each carat into 12 grains, by ſmall ſets of weights uſed for this purpoſe. The actual quantity of gold uſed for this purpoſe is half a pfenning, or $\frac{1}{512}$ of a real mark = 128 ſtandard parts, or about 7 grains Troy. The aſſay grain is further divided into halves and quarters. The *Aſſay mark for Silver* is divided as the real mark for this metal, namely, into 16 loths, and each loth into 18 grains, and the grain into halves and quarters; and the real weight of the ſilver aſſay mark is twice that of gold, or one pfenning.

The German aſſayers and mineralogiſts have alſo the *Docimaſtic Centner*, which has generally the actual weight of one quentchen (equal to 56.34 grains Troy) but is ſubdivided into 100 docimaſtic pounds, each of which therefore is equivalent to about $\frac{1}{2}$ grain Troy.

The moſt common meaſure of length in Germany is the *Rhinland foot*, to which ſtandard the foot, ell, &c. of the different ſtates is uſually compared.

With regard to the length of this meaſure in Engliſh inches, the *Pied du Rhin* is ſaid in Peuchet's Dict. de Commerce, to be = 11 inch. : 7 lines, of the old French *pied de roi*, which is = 12.341 Engliſh inches. Hence we have the following numbers, viz. 1 Rhinland foot = 12.341, Engliſh inches, and therefore 1 Rhinland inch = 1.02842 Engliſh inches, and 1 cubic inch Rhinland = 1.08769 Engliſh cubic inches, = 274.648 Troy grains of diſtilled water = 286.31. Nuremb. grains.

On the other hand, Klaproth in his analyſis of the Carlſbad water, and in the other parts of his works, employs the cubic inch, which, he ſays, holds 290 of the true Nuremburg grains of diſtilled water, and which appears to be as common a ſtandard of length among the German chemiſts as the Nuremburg is of weight. Now according to Gren, 290 Nuremb. grains, = 278.187 Troy grains, = 1.10169 Engliſh cubic inch. of water, and the cube root of 1.101700+ (which hardly differs from 1.101693) is = 1.032812. So that the inch uſed by Klaproth is probably the Rhinland inch, which by this eſtimation is = 1.032812 Engliſh inches, and by the former is = 1.02842, Engliſh inches, the difference being only about .0044.

We may therefore without danger of material error, conſider the inch uſed by moſt of the German chemiſts (unleſs otherwiſe ſpecified) as that which, when cubed, contains 290 Nuremburg grains of water, and as having the following proportions with the Engliſh.

Germ. feet or inches.		*Eng. feet or inches.*	*Germ. cub. inch.*		*E. cub. inch.*
1.	=	1.0328	1	=	1.1017
2.	=	2.0656	2	=	2.2034
3	=	3.0984	3	=	3.3051
4	=	4.1312	4	=	4.4068
5	=	5.1640	5	=	5.5085
6	=	6.1969	6	=	6.6102
7	=	7.2297	7	=	7.7119
8	=	8.2625	8	=	8.8136
9	=	9.2953	9	=	9.9153

When 1 German cubic inch weighs or contains 1 Nuremburg grain; 1 cubic inch Engliſh weighs or contains .8707 Troy grain.

TABLES RELATING TO THE THREE THERMOMETERS COMMONLY USED.

Under the article Thermometer in Appendix. I. we have mentioned that the thermometers commonly employed, are *Fahrenheit's*, in this country univerſally; *Reaumur's* on moſt parts of the continent; and lately *Celſius's*, or the Swediſh thermometer, has been adopted in France under the name of the *Centigrade*. Both the zero and the diviſions of each of theſe three differ. The following three tables will give the correſpondences of each thermometer for every degree of each from 212° of Fahr. the boiling point of water, to — 40, the freezing point of mercury.

Table for Fahrenheit's Thermometer.

Fahr.	*Reau.*	*Cent.*
212	80.00	100.00
211	79.55	99.44
210	79.11	98.88
209	78.66	98.33
208	78.22	97.77
207	77.77	97.22
206	77.33	96.66
205	76.88	96.11
204	76.44	95.55
203	76.00	95.00
202	75.55	94.44
201	75.11	93.88
200	74.66	93.33
199	74.22	92.77
198	73.77	92.22
197	73.33	91.66
196	72.88	91.11
195	72.44	90.55
194	72.00	90.00
193	71.55	89.44
192	71.11	88.88
191	70.66	88.33
190	70.22	87.77
189	69.77	87.22
188	69.33	86.66
187	68.88	86.11
186	68.44	85.55
185	68.00	85.00
184	67.55	84.44
183	67.11	83.88
182	66.66	83.33
181	66.22	82.77
180	65.77	82.22
179	65.33	81 66
178	64.88	81.11
177	64.44	80.55
176	64.00	80.00
175	63.55	79.44
174	63.11	78.88
173	62.66	78.33
172	62.22	77.77
171	61.77	77.22
170	61.33	76.66
169	60.88	76.11
168	60.44	75.55
167	60.00	75.00
166	59.55	74.44
165	59.11	73.88
164	58.66	73.33
163	58.22	72.77
162	57.77	72.22
161	57.33	71.66
160	56.88	71.11
159	56.44	70.55
158	56.00	70.00
157	55.55	69.44
156	55.11	68.88
155	54.66	68.33
154	54.22	67.77
153	53.77	67.22
152	53.33	66.66
151	52.88	66.11
150	52.44	65.55
149	52.00	65.00
148	51.55	64.44
147	51.11	63.88
146	50.66	63.33
145	50 22	62.77
144	49.77	62.22
143	49.33	61.66
142	48.88	61.11
141	48.44	60.55
140	48.00	60.00
139	47.55	59.44
138	47.11	58.88
137	46.66	58.33
136	46.22	57.77
135	45.77	57.22
134	45.33	56.66
133	44.88	56.11
132	44.55	55.55
131	44.00	55.00
130	43.55	54.44
129	43.11	53.88
128	42.66	53.33
127	42.22	52.77
126	41.77	52.22
125	41.33	51.66
124	40.88	51.11
123	40.44	50.55
122	40.00	50.00
121	39.55	49.44
120	39.11	48.88
119	38.66	48.33
118	38.22	48.77
117	37.77	47.22
116	37.33	46.66
115	36.88	46.11
114	36.44	45.55
113	36.00	45.00
112	35.55	44.44
111	35.11	43.88
110	34.66	43.33
109	34.22	42.77
108	33.77	42.22
107	33.33	41.66
106	32.88	41.11
105	32.44	40.55
104	32.00	40.00
103	31.55	39.44
102	31.11	38.88
101	30.66	38.33
100	30.22	37.77
99	29.77	37.22
98	29.33	36.66
97	28.88	36.11
96	28.44	35.55
95	28.00	35.00
94	27.55	34.44
93	27.11	33.88
92	26.66	33.33
91	26.22	32.77
90	25.77	32.22
89	25.33	31.66
88	24.88	31.11
87	24.44	30.55

Fahr.	*Reau.*	*Cent.*	*Fahr.*	*Reau.*	*Cent.*	*Fahr.*	*Reau.*	*Cent.*
86	24.00	30.00	43	4.88	6.11	0	-14.22	-17.77
85	23.55	29.44	42	4.44	5.55	-1	14.66	18.33
84	23.11	28.88	41	4.00	5.00	2	15.11	18.88
83	22.66	28.33	40	3.55	4.44	3	15.55	19.44
82	22.22	27.77	39	3.11	3.88	4	16.00	20.00
81	21.77	27.22	38	2.66	3.33	5	16.44	20.55
80	21.33	26.66	37	2.22	2.77	6	16.88	21.11
79	20.88	26.11	36	1.77	2.22	7	17.33	21.66
78	20.44	25.55	35	1.33	1.66	8	17.77	22.22
77	20.00	25.00	34	0.88	1.11	9	18.22	22.77
76	19.55	24.44	33	0.44	0.55	10	18.66	23.33
75	19.11	23.88	32	0.	0	11	19.11	23.88
74	18.66	23.33	31	-0.44	-0.55	12	19.55	24.44
73	18.22	22.77	30	0.88	1.11	13	20.00	25.00
72	17.77	22.22	29	1.33	1.66	14	20.44	25.55
71	17.33	21.66	28	1.77	2.22	15	20.88	26.11
70	16.88	21.11	27	2.22	2.77	16	21.33	26.66
69	16.44	20.55	26	2.66	3.33	17	21.77	27.22
68	16.00	20.00	25	3.11	3.88	18	22.22	27.77
67	15.55	19.44	24	3.55	4.44	19	22.66	28.33
66	15.11	18.88	23	4.00	5.00	20	23.11	28.88
65	14.66	18.33	22	4.44	5.55	21	23.55	29.44
64	14.22	17.77	21	4.88	6.11	22	24.00	30.00
63	13.77	17.22	20	5.33	6.66	23	24.44	30.55
62	13.33	16.66	19	5.77	7.22	24	24.88	31.11
61	12.88	16.11	18	6.22	7.77	25	25.33	31.66
60	12.44	15.55	17	6.66	8.33	26	25.77	32.22
59	12.00	15.00	16	7.11	8.88	27	26.22	32.77
58	11.55	14.44	15	7.55	9.44	28	26.66	33.33
57	11.11	13.88	14	8.00	10.00	29	27.11	33.88
56	10.66	13.33	13	8.44	10.55	30	27.55	34.44
55	10.22	12.77	12	8.88	11.11	31	28.00	35.00
54	9.77	12.22	11	9.33	11.66	32	28.44	35.55
53	9.33	11.66	10	9.77	12.22	33	28.88	36.11
52	8.88	11.11	9	10.22	12.77	34	29.33	36.66
51	8.44	10.55	8	10.66	13.33	35	29.77	37.22
50	8.00	10.00	7	11.11	13.88	36	30.22	37.77
49	7.55	9.44	6	11.55	14.44	37	30.66	38.33
48	7.11	8.88	5	12.00	15.00	38	31.11	38.88
47	6.66	8.33	4	12.44	15.55	39	31.55	39.44
46	6.22	7.77	3	12.88	16.11	40	32.00	40.00
45	5.77	7.22	2	13.33	16.66			
44	5.33	6.66	1	13.77	17.22			

Table for Reaumur's Thermometer.

Reau	*Cent.*	*Fahr.*	*Reau*	*Cent.*	*Fahr.*	*Reau*	*Cent.*	*Fahr.*
80	100.	212.	42	52.5	126.5	4	5.	41.
79	98.75	209.75	41	51.25	124.25	3	3.75	38.75
78	97.5	207.5	40	50.	122.	2	2.5	36.5
77	96.25	205.25	39	48.75	119.75	1	1.25	34.25
76	95.	203	38	47.5	117.5	0	0	32
75	93.75	200.75	37	46.25	115.25	−1	−1.25	29.75
74	92.5	198.5	36	45	113.	2	2.5	27.5
73	91.25	196.25	35	43.75	110.75	3	3.75	25.25
72	90	194.	34	42.5	108.5	4	5	23
71	88.75	191.75	33	41.25	106.25	5	6.25	20.75
70	87.5	189.5	32	40.	104	6	7.5	18.5
69	86.25	187.25	31	38.75	101.75	7	8.75	16.25
68	85	185.	30	37.5	99.5	8	10.	14.
67	83.75	182.75	29	36.25	97.25	9	11.25	11.75
66	82.5	180.5	28	35	95.	10	12.5	9.5
65	81.25	178.25	27	33.75	92.75	11	13.75	7.25
64	80	176.	26	32.5	90.5	12	15.	5.
63	78.75	173.75	25	31.25	88.25	13	16.25	2.75
62	77.5	171.5	24	30	86.	14	17.5	0.5
61	76.25	169.25	23	28.75	83.75	15	18.75	−1.75
60	75.	167.	22	27.5	81.5	16	20.	4.
59	73.75	164.75	21	26.25	79.25	17	21.25	6.25
58	72.5	162.5	20	25	77.	18	22.5	8.5
57	71.25	160.25	19	23.75	74.75	19	23.75	10.75
56	70.	158.	18	22.5	72.5	20	25.	13.
55	68.75	155.75	17	21.25	70.25	21	26.25	15.25
54	67.5	153.5	16	20	68	22	27.5	17.5
53	66.25	151.25	15	18.75	65.75	23	28.75	19.75
52	65.	149	14	17.5	63.5	24	30.	22.
51	63.75	146.75	13	16.25	61.25	25	31.25	24.25
50	62.5	144.5	12	15	59.	26	32.5	26.5
49	61.25	142.25	11	13.75	56.75	27	33.75	28.75
48	60.	140.	10	12.5	54.5	28	35	31
47	58.75	137.75	9	11.25	52.25	29	36.25	33.25
46	57.5	135.5	8	10	50	30	37.5	35.5
45	56.25	133.25	7	8.75	47.75	31	38.75	37.75
44	55	131.	6	7.5	45.5	32	40.	40.
43	53.75	128.75	5	6.25	43.25			

Table for the Centigrade Thermometer.

Cent.	*Reau.*	*Fahr.*	*Cent.*	*Reau.*	*Fahr.*	*Cent.*	*Reau.*	*Fahr.*
100	80.	212.	53	42.4	127.4	6	4.8	42.8
99	79.2	210.2	52	41.6	125.6	5	4.	41.
98	78.4	208.4	51	40.8	123.8	4	3.2	39.2
97	77.6	206.6	50	40.	122.	3	2.4	37,4
96	76.8	204.8	49	39.2	120.2	2	1.6	35.6
95	76.	203.	48	38.4	118.4	1	0.8	33.8
94	75.2	201.2	47	37.6	116.6	0	0.	32.
93	74.4	199.4	46	36.8	114.8	−1	−0.8	30.2
92	73.6	197.6	45	36.	113.	2	1.6	28.4
91	72.8	195.8	44	35.2	111.2	3	2.4	26.6
90	72.	194.	43	34.4	109.4	4	3.2	24.8
89	71.2	192.2	42	33.6	107.6	5	4.	23.
88	70.4	190.4	41	32.8	105.8	6	4.8	21.2
87	69.6	188.6	40	32.	104.	7	5.6	19.4
86	68.8	186.8	39	31.2	102.2	8	6.4	17.6
85	68.	185.	38	30.4	100.4	9	7.2	15.8
84	67.2	183.2	37	29.6	98.6	10	8.	14.
83	66.4	181.4	36	28.8	96.8	11	8.8	12.2
82	65.6	179.6	35	28.	95.	12	9.6	10.4
81	64.8	177.8	34	27.2	93.2	13	10.4	8.6
80	64.	176.	33	26.4	91.4	14	11.2	6.8
79	63.2	174.2	32	25.6	89.6	15	12.	5.
78	62.4	172.4	31	24.8	87.8	16	12.8	3.2
77	61.6	170.6	30	24.	86	17	13.6	1.4
76	60.8	168.8	29	23.2	84.2	18	14.4	−0.4
75	60.	167.	28	22.4	82.4	19	15.2	2.2
74	59.2	165.2	27	21.6	80.6	20	16.	4.
73	58.4	163.4	26	20.8	78.8	21	16.8	5.8
72	57.6	161.6	25	20.	77.	22	17.6	7.6
71	56.8	159.8	24	19.2	75.2	23	18.4	9 4
70	56.	158.	23	18.4	73.4	24	19.2	11.2
69	55.2	156.2	22	17.6	71.6	25	20.	13
68	54.4	154.4	21	16.8	69.8	26	20.8	14.8
67	53.6	152.6	20	16.	68.	27	21.6	16.6
66	52.8	150.8	19	15.2	66.2	28	22.4	18.4
65	52.	149.	18	14.4	64.4	29	23.2	20.2
64	51.2	147.2	17	13.6	62.6	30	24.	22.
63	50.4	145.4	16	12.8	60.8	31	24.8	23.8
62	49.6	143.6	15	12.	59	32	25.6	25.6
61	48.8	141.8	14	11.2	57.2	33	26.4	27.4
60	48.	140.	13	10.4	55.4	34	27.2	29.2
59	47.2	138.2	12	9.6	53.6	35	28.	31.
58	46.4	136.4	11	8.8	51.8	36	28.8	32.8
57	45.6	134.6	10	8.	50.	37	29.6	34.6
56	44.8	132.8	9	7.2	48.2	38	30.4	36.4
55	44.	131.	8	6.4	46.4	39	31.2	38.2
54	43.2	129.2	7	5.6	44.6	40	32	40

TABLES FOR REDUCING THE DEGREES OF BEAUMÉ's AREOMETER INTO THEIR CORRESPONDING EXPRESSION OF SPECIFIC GRAVITY.

Beaumé's Areometer or Hydrometer, though not a very correct inſtrument, is that which from its convenience is employed very commonly by the French chemiſts, who are in the habit of expreſſing the ſtrength or ſpecific gravity of the acids, alcohol, &c. which they employ by the ſcale of this inſtrument. It is deſcribed by Beaumé in his Elemens de Pharmacie, p. 466.

The form of this inſtrument is that of the common hydrometer, that is, a lengthened bulb or ball with a long narrow ſtem riſing from it, which laſt is graduated, and the inſtrument is ſo poiſed that it floats with nearly the whole of the ſtem above the level of the heavieſt liquid whoſe denſity it is to indicate, and with nearly the whole of the ſtem immerſed when the lighteſt liquid is uſed. A ſingle inſtrument would in ſtrictneſs ſuffice to indicate the denſity of every liquid from the lighteſt alcohol to the heavieſt acid, which would include a range of actual ſpecific gravity from about .8 to 2. (water being = 1.) But an inſtrument of this kind muſt be either inconveniently long, or the ſtem muſt be very wide, and the degrees too minute for tolerable accuracy. Beaumé therefore very judiciouſly divided it into two ſcales, one of which is the areometer for ſpirits and liquors lighter than water, and the other the areometer for ſalts or liquids heavier than water. He has further diſtinguiſhed them by inverting the ſcales, that is to ſay, in the inſtrument for ſalts the 0. or zero is at diſtilled water, and the numbers increaſe with the *increaſing* denſity of the liquors for which it is uſed; whereas in the inſtrument for ſpirits the numbers increaſe from the zero with the *decreaſing* denſity. Hence it is neceſſary to deſcribe theſe two inſtruments ſeparately.

The hydrometer for ſalts was made by Beaumé in the following way: the inſtrument was firſt immerſed in water at 18.75° Reaum. = about 50°. Fahr. and loaded with mercury dropped into the bulb till it ſunk ſo low that only the very top of the ſtem was out of water, which point was marked as the 0. of the ſcale. The inſtrument was then removed to a ſolution of common ſalt, containing 15 parts (by weight) of ſalt to 85 parts of water, and the height to which it floated was marked on the ſtem as 15° of the ſcale. The interval between theſe two points of immerſion being therefore conſidered as 15 degrees, the ſcale was extended to any required number, merely by marking off with compaſſes an equal length of the ſtem, and the whole was farther ſubdivided in the ſame way. Beaumé conſidered therefore that every degree of the inſtrument indicated a denſity of liquid equal to that of a ſolution of common ſalt, in which the number of parts of ſalt in 100 parts, by weight, of the ſolution, was equal to the ſame number on the ſcale at which the inſtrument floated. But as the diameter of the ſtem is ſeldom equal throughout, he propoſes to remedy the incorrectneſs produced by this circumſtance, where greater accuracy is required, by immerſing the inſtrument ſucceſſively in ſolutions containing 5, 10, 15, &c. per cent. of ſalt, and marking theſe points as 5, 10, 15, &c. on the ſcale, or, to be ſtill more accurate, all the individual degrees may be found by actual experiment. In fact, even where the ſtem of the inſtrument is perfectly cylindrical, this would be the only way to enſure perfect accuracy, as a diviſion of equal diſtances on the ſcale would not preciſely correſpond with an equal increaſe of the percentage of ſalt in the ſolution.

The ſcale of this inſtrument does not properly extend higher than about 30°. as this is the point of ſaturation of water with ſalt, but it may be lengthened at pleaſure by marking off equal diſtances on the ſcale.

The following table of correſpondence between Beaumé's areometer for ſalts and the actual expreſſion of ſpecific gravity has been calculated by Mr. Nicholſon, for every third degree (Phil. Journ. 4to. vol. i. p. 38.) from the datum of Morveau that the 66th degree correſponds with 1.848 ſp. gr. We have added to it the ſpecific gravities of moſt of the correſponding ſolutions of common ſalt in water as high as 30°. of the inſtrument, as given by Haſſenfratz in the 28th vol. of the An. de Chim. p. 298. which ought therefore to be the ſame, but which actually differ in no inconſiderable degree.

We have further added the correſponding ſpecific gravities with many of the degrees of the hydrometer from 18° to 45° as given by R. Bingley, Eſq. King's Aſſay-maſter of the Mint, (Philoſophical Magazine, vol. xii.) from actual experiments with a Paris hydrometer. This includes a ſpecific gravity from 1.150 to 1.435, which, with acids, is ſufficient for moſt of the purpoſes of the aſſayer or mineralogiſt.

Beaumé's Hydrometer for Salts. (Temperature 55° Fahr.)

Beaumé	*Nicholſon*	*Haſſenfratz*	*Bingley*
1 = Sp. Gr.	1.000 =	1.0000 =	
2		1.0128	
3	1.020	1.0192	
4		1.0256	
5		1.0320	
6	1.040	1.0384	
7		1.0448	
8		1.0502	
9	1.064	1.0576	
10		1.0640	
12	1.089	1.0775	
14		1.0910	
15	1.114		
16		1.1045	
18	1.140	1.1182	1.150
20		1.1320	1.167
21	1.170		
22		1.1462	
24	1.200	1.1608	
26		1.1760	1.216
27	1.230		
28		1.1920	1.233
29			1.250
30	1.261	1.2100	1.267
31 = Sp. Gr.			1.275
32			1.283
33	1.295		
34			1.300
35			1.312
36	1.333		1.313
37			1.342
38			1.350
39	1.373		1.358
40			1.367
41			1.383
42	1.414		1.400
43			1.416
45	1.455		1.435
48	1.500		
51	1.547		
54	1.597		
57	1.659		
60	1.717		
63	1.779		
66	1.848		
69	1.920		
72	2.000		

The Hydrometer for Spirits is conſtructed exactly on the ſame principle, and the mode of graduation is alſo the ſame, that is, by a ſolution of ſalt, and not by mixtures of alcohol and water of different denſities. In this hydrometer the zero is placed not at the point to which the ſtem ſinks in diſtilled water, but at the point to which it falls in a mixture of 10 parts of ſalt and 90 of water. The interval between this point and that of diſtilled water is marked on the ſcale as 10 degrees, and this ſcale is continued upwards on the ſtem ſimply by meaſuring equal portions by the compaſſes. The 10th degree of the ſpirit hydrometer correſponds with the o. of the ſalt hydrometer, and it is certainly a defect that the ingenious inventor ſhould have introduced this deviation from what is obviouſly the natural zero in each ſcale, namely, the point of immerſion in diſtilled water; ſince it was as eaſy to obtain a meaſure for 10 degrees of the ſcale of the ſpirit hydrometer by beginning the notation 10 degrees below zero as at this point.

The correſpondence between Beaumé's ſpirit hydrometer and the real expreſſion of ſpecific gravity has alſo been calculated by Mr. Nicholſon, and on the following data: viz. Beaumé found that a ſpirit of .842 ſp. gr. at 32°. Fahr. gave 37 degrees of his hydrometer; and that a mixture of two parts, by weight, of this ſpirit with 30 of water gave 12 degrees of the hydrometer at the ſame temperature.

This mixture is found by Gilpin's valuable tables to be = .9915 ſpecific gravity at this temperature, and theſe terms, viz. .842 and .9915 become .832 and .9905 at 55° Fahr. or 10. Reaum. the ſtandard temperature of the graduation of theſe inſtruments. We have given in the article Alcohol, p. 30. Vol. 1. of this work, Beaumé's table of the denſity of different mixtures of alcohol and water expreſſed in the degrees of his hydrometer, with the correſponding ſpecific gravities as given by Haſſenfratz (An. Chim. tom. xxxiii. p. 11.) we ſhall here repeat the latter as a compariſon with thoſe given by Mr. Nicholſon, and which will further ſhew the degree of incorrectneſs of Beaumé's inſtrument.

Beaumés Hydrometer for Spirits. (Temperature 55° F).

Beaumé.		*Nicholſon.*		*Haſſenfratz.*
10	=	1.0000	=	1.0000
11	=	.990	=	
12	=	.985	=	.9863
13	=	.977	=	.9796
14	=	.970	=	.9730
15	=	.963	=	.9666
16	=	.955	=	.
16½	=		=	.9569
17	=	.949	=	
18	=	.942	=	.9474
19	=	.935	=	.
19½	=		=	.9382
20	=	.928	=	
21	=	.922	=	.9290
22	=	.915	=	
23	=	.909	=	.9172
24	=	.903	=	
25	=	.897	=	.9057
26	=	.892	=	
27	=	.886	=	0.8944
28	=	.880	=	
29	=	.874	=	
29½	=		=	.8807
30	=	.871	=	
31	=	.867	=	
32	=	.856	=	.8675
33	=	.852	=	
34	=	.847	=	.8571
35	=	.842	=	
36	=	.837	=	
37	=	.832	=	.8421
38	=	.827	=	
39	=	.822	=	
40	=	.817	=	.8276

TABLE OF THE SPECIFIC GRAVITY OF WATER AT EVERY DEGREE OF TEMPERATURE FROM 30° TO 80° FAHR.

Fahr.	*Sp. gr.*	*Fahr.*	*Sp. gr.*	*Fahr.*	*Sp. gr.*	*Fahr.*	*Sp. gr.*
30° —	1.00074	43° —	1.00090	56° —	1.00031	69° —	0.99906
31	1.00078	44	1.00088	57	1.00024	70	0.99894
32	1.00082	45	1.00086	58	1.00016	71	0.99882
33	1.00085	46	1.00083	59	1.00008	72	0.99869
34	1.00088	47	1.00080	60	1.00000	73	0.99856
35	1.00090	48	1.00076	61	0.99991	74	0.99843
36	1.00092	49	1.00072	62	0.99981	75	0.99830
37	1.00093	50	1.00068	63	0.99971	76	0.99816
38	1.00094	51	1.00063	64	0.99961	77	0.99802
39	1.00094	52	1.00057	65	0.99950	78	0.99788
40	1.00094	53	1.00051	66	0.99939	79	0.99774
41	1.00093	54	1.00045	67	0.99928	80	0.99759
42	1.00092	55	1.00038	68	0.99917		

The above Table is that which is given by Mr. Gilpin in the 84th Vol. of the Philoſophical Tranſactions, and is of eſſential uſe for taking the ſpecific gravities both of ſolids and fluids, by enabling the operator to reduce the weight or bulk of the diſtilled water employed in any caſe to that which it would have at any other common temperature, and particularly to 60° which is the uſual ſtandard. Thus, for example, ſince the ſpecific gravity of water at 47°. is 1.0008, and at 60°. is 1.00000, (and conſequently 10008 grs. at 47° are equal in bulk to 10000 grs. at 60°) it follows that it would require 252.708 grs. at 47° to equal the ſpace of a cubic inch; for 10000 : 10008 :: 252.506. (the weight of a cubic inch at 60°.) :252.708. The remarkable anomaly of the ſpecific gravity of water *decreaſing* through all the degrees of temperature below 40°. or thereabouts, that it remains uncongealed, has been noticed under the article *Water*, but the difference for one or two degrees above or below 40° is ſo trifling, that it has hardly yet been aſcertained with perfect accuracy.

TABLES RELATIVE TO THE STRENGTH OF ACIDS AND THEIR SATURATION WITH DIFFERENT BASES.

N.B. The following five Tables are extracted from Mr. Kirwan's "Additional Observations on the Proportion of Real Acid, &c." Dublin, 1799.

I.

Table of the quantities of Real Acid in 100 parts of Sulphuric Acid of different denſities at 60°. Fahr.

100 *parts* *Sp. gravity.*	*Real Acid.*	100 *parts* *Sp. gravity.*	*Real Acid.*	100 *parts* *Sp. gravity.*	*Real Acid.*
2.0000	[illegible]	1.6503	62.50	1.3360	35.71
1.9859	88.39	1.6407	61.61	1.3254	34.82
1.9719	87.50	1.6312	60.71	1.3149	33.93
1.9579	86.61	1.6217	59.82	1.3102	33.03
1.9439	85.71	1.6122	58.93	1.3056	32.14
1.9299	84.82	1.6027	58.03	1.2951	31.25
1.9168	83.93	1.5932	57.14	1.2847	30.35
1.9041	83.04+	1.5840	56.25	1.2757	29.46
1.8914	82.14	1.5748	55.36+	1.2668	28.57
1.8787	81.25	1.5656	54.46	1.2589	27.68+
1.8660	80.36	1.5564	53.57	1.2510	26.78
1.8542	79.46	1.5473	52.68	1.2415	25.89
1.8424	78.57	1.5385	51.78	1.2320	25.—
1.8306	77.68	1.5292	50.89	1.2210	24.10
1.8188	76.79+	1.5202	50.00	1.2101	23.21
1.8070	75.89	1.5112	49.11+	1.2009	22.32
1.7959	75.—	1.5022	48.21	1.1918	21.43+
1.7849	74.11	1.4933	47.32	1.1836	20.53
1.7738	73.22	1.4844	46.43	1.1746	19.64
1.7629	72.32	1.4755	45.53	1.1678	18.75
1.7519	71.43	1.4666	44.64	1.1614	17.85
1.7416	70.54+	1.4427	43.75	1.1531	16.96
1.7312	69.64	1.4189	42.86	1.1398	16.07
1.7208	68.75	1.4099	41.96	1.1309	15.18+
1.7104	67.86	1.4010	41.07	1.1208	14.28
1.7000	66.96	1.3875	40.18	1.1129	13.39
1.6899	66.07	1.3768	39.28	1.1011	12.50
1.6800	65.18	1.3663	38.39	1.0955	11.60
1.6701	64.28	1.3586	37.50		
1.6602	63.39	1.3473	36.60		

II.

In 100 parts of Nitric Acid of different denſities at 60°. Fahr.

100 *parts* *Sp. gravity.*	*Real Acid.*	100 *parts* *Sp. gravity.*	*Real Acid.*	100 *parts* *Sp. gravity.*	*Real Acid.*
1.5543	73.54	1.4018	51.47	1.2586	32.35
1.5295	69.86	1.3975	50.74	1.2500	31.62
1.5183	69.12	1.3925	50.00	1.2464	30.88
1.5070	68.39	1.3875	49.27	1.2419	30.15
1.4957	67.65	1.3825	48.53	1.2374	29.41
1.4844	66.92	1.3775	47.80	1.2291	28.68
1.4731	66.18	1.3721	47.06	1.2209	27.94
1.4719	65.45	1.3671	46.33	1.2180	27.21+
1.4707	64.71	1.3621	45.59	1.2152	26.47
1.4695	63.98+	1.3571	44.86+	1.2033	25.74+
1.4683	63.24	1.3521	44.12	1.2015	25.00
1.4671	62.51	1.3468	43.38	1.1963	24.26
1.4640	61.77	1.3417	42.65	1.1911	23.53
1.4611	61.03	1.3364	41.91	1.1845	22.79
1.4582	60.30	1.3315	41.18	1.1779	22.06
1.4553	59.56	1.3264	40.44	1.1704	21.32
1.4524	58.83	1.3212	39.71	1.1639	20.59
1.4471	58.09	1.3160	38.97	1.1581	19.85
1.4422	57.36	1.3108	38.34	1.1524	19.12
1.4373	56.62	1.3056	37.50	1.1421	18.48
1.4324	55.89	1.3004	36.77	1.1319	1765+
1.4275	55.15	1.2911	36.03	1.1284	16.91
1.4222	54.12+	1.2812	35.30+	1.1241	16.17
1.4171	53.68	1.2795	34.56	1.1165	15.44
1.4120	52.94	1.2779	33.82	1.1111	14.70
1.4069	52.21	1.2687	33.09	1.1040	13.27

III.

In 100 parts of Muriatic Acid of different denſities at 60°. Fahr.

100 *parts* *Sp. gravity.*	*Real Acid.*	100 *parts* *Sp. gravity*	*Real Acid.*	100 *parts* *Sp. gravity.*	*Real Acid.*
1.196	25.28	1.147	19.09	1.1036	13.41
1.191	24.76	1.1414	18.57	1.0984	12.90
1.187	24.25	1.1396	18.06	1.0942	12.38
1.183	23.73	1.1358	17.54	1.0910	11.86
1.179	23.22	1.1320	17.02	1.0868	11.35
1.175	22.70	1.1282	16.51	1.0826	10.83
1.171	22.18	1.1244	15.99	1.0784	10.32
1.167	21.67	1.1206	15.48	1.0742	9.80
1.163	21.15	1.1168	14.96	1.0630	8.25
1.159	20.64	1.1120	14.44	1.0345	5.16
1.155	20.12	1.1078	13.93	1.0169	2.58
1.151	19.60				

The explanation of Mr. Kirwan's term Real Acid, and the method of eſtimating its quantity in any mixture of acid and water, whoſe ſpecific gravity is known, have been already explained under the article NITRIC ACID, p. 145. and SULPHURIC ACID, p. 273. of this volume, and need not be here repeated at length. It may juſt be obſerved, however, that by *real ſulphuric acid* the author means an acid of the ſame denſity as that which forms one of the two conſtituent parts of perfectly dry and ignited *ſulphat of potaſh*—by *real nitric acid*, he underſtands the acid of perfectly dry *nitrat of ſoda*—and by *real muriatic acid*, the acid of ignited *muriat of potaſh*.

In the above Tables the differences between the individual numbers are ſo ſmall as to anſwer moſt practical purpoſes without further calculation, ſo that any ſpecific gravity which is not ſet down in the Table, or *extra-tabular*, may generally be referred to that in the Table to which it is the neareſt. If, however, a greater approximation to accuracy be required, the contents per cent. in real acid of any extra-tabular ſpecific gravity may be found by the Rule of Proportion in the following way, as given by Mr. Kirwan:

Find the difference between the next higher and lower tabular ſpecific gravities $= D$, and alſo the difference between their acid contents $= D'$.

Then find the difference between the extra-tabular ſpecific gravity and the next upper or lower tabular ſpecific gravity, whichever it is neareſt to $= d$.

Then the difference between the quantity of real acid of the extra-tabular, and that of the neareſt tabular ſpecific gravity $(= d')$ will be found by the following ſimple Rule of Proportion, $D : D' :: d : d'$, therefore $d' = \frac{D'd}{D}$ and by adding d' to the acid contents of the loweſt tabular ſpecific gravity, or ſubtracting it from the upper, according to whichever is taken, the quantity ſought will be given.

To illuſtrate this by a ſingle example: What is the quantity of real acid in 100 parts of ſulphuric acid of 1.790 ſpecific gravity?

By inſpecting the Table I find that 1.790 is between 1.7959 and 1.7849, conſequently the tabular numbers concerned, with their reſpective differences, will be as follows:

	Sp. Gr.	Real Acid.	
$D = 110$	17959	75.00	$D' = .89$
	17849	74.11	

and d in this caſe is the difference between 17900 and $17849 = 51$. The given proportions therefore are, As $110 : .89 :: 51 : d'$, therefore $d' = .413$ nearly, which added to 74.11 makes 74.523 as the quantity per cent. of real acid in ſulphuric acid of 1.790 ſpecific gravity.

This method, however, is not perfectly accurate, ſince it is found that the affinity of ſulphuric acid to water proceeds in a decreaſing ratio as the quantity of water increaſes, and conſequently that the increaſe in ſpecific gravity for equal additions of real acid purſues an increaſing ratio from the bottom of the ſcale to the top. Therefore the value of d' as above eſtimated is rated a little too low.

By a ſimilar method the ſpecific gravity of any acid, whoſe contents per cent. of real acid are known, but extra-tabular, may be found. Find D and D' as before and d' is already given. Then $\frac{Dd'}{D'} = d$ and d added to the lower ſpecific gravity, or ſubtracted from the upper, gives the ſpecific gravity ſought.

IV.

Table of the quantity of Real Acid required to ſaturate 100 parts of Alkalies and earths.

(*Kirwan.*)

100 *Parts of*	*Sulphuric A.*	*Nitric A.*	*Muriatic A.*	*Carbonic A.*
Potaſh	82.48	84.96	56.3	105.
Soda	127.68	135.71	73.41	66.8
Ammonia	383.8	247.82	171.	Variable
Barytes	50.	56.	31.8	28.2
Strontian	72.41	85.56	46.	43.2
Lime	143.	179.5	84.488	81.81
Magneſia	172.64	210.	111.35	200.

V.

Table of the quantity of Alkalies and Earths required to ſaturate 100 parts of Real Sulphuric, Nitric, Muriatic, and Carbonic Acids. (*Kirwan.*)

100 *Parts of*	*Potaſh.*	*Soda.*	*Ammonia.*	*Barytes.*	*Strontian.*	*Lime.*	*Magneſia.*
Sulphuric A.	121.48	78.32	26.05	200.	138.	70.	57.92
Nitric A.	117.7	73.43	40.35	178.12	116.86	55.7	47.64
Muriatic A.	177.6	136.2	58.48	314.46	216.21	118.3	89.8
Carbonic A.	95.1	149.6	——	354.5	231.	122.	50.

From the two laſt Tables (ſuppoſing them to be accurate, and on the whole they appear to be the moſt ſo of any that have been ever given) the proportional quantity of acid and baſe in any neutral ſalt may be found by a ſimple calculation. In this ſtate the ſalt is ſuppoſed to be abſolutely free from water of cryſtallization, and at the utmoſt degree of dryneſs. Such a ſtate however only can exiſt with part of the above compounds, form any of them cannot be expoſed to a heat ſufficient to expel the water which they contain without at the ſame time driving off or decompoſing a portion of the acid or the baſe. This is the caſe with all the ammoniacal ſalts, with moſt of the nitrats, with the alkaline carbonats, with muriat of magneſia, &c. ſo that there ſtill is wanting to complete the ſubject a Table of the actual compoſition of theſe and other ſalts at different degrees of dryneſs. This however we have not thought it neceſſary to add in this place, as we have already mentioned the compoſition of moſt of them under their reſpective heads, and it muſt be acknowledged that the conſiderable difference which is found in the eſtimations of chemiſts of eminence, ſhews the neceſſity of further reſearches, and of a much greater accuracy regulating the temperature at which deſiccation is made, than is commonly obſerved.

TABLES OF SIMPLE AFFINITY.

(*Copied from* HENRY'*s Epitome of Chemistry, p.* liii.)

OXYGEN.

Carbon,
Charcoal,
Manganeſe,
Zinc,
Iron,
Tin,
Antimony,
Hydrogen
Phoſphorus,
Sulphur,
Arſenic,
Nitrogen,
Nickel,
Cobalt,
Copper,
Biſmuth,
Caloric ?
Mercury,
Silver,
Arſenous acid,
Nitric oxide,
Gold,
Platina,
Carbonic oxide,
Muriatic acid,
White oxide of Manganeſe,
White oxide of Lead.

OXYGEN.*

Titanium,
Manganeſe,
Zinc,
Iron,
Tin,
Uranium,
Molybdena,
Tungſten,
Cobalt,
Antimony,
Nickel,
Arſenic,
Chrome,
Biſmuth,
Lead,
Copper,
Tellurium,
Platina,
Mercury,
Silver,
Gold.

CARBON.

Oxygen,
Iron
Hydrogen.

NITROGEN.

Oxygen,
Sulphur ?
Phoſphorus,
Hydrogen.

HYDROGEN.

Oxygen
Sulphur,
Carbon,
Phoſphorus,
Nitrogen.

SULPHUR.
PHOSPHORUS ?

Potaſh,
Soda,
Iron,
Copper,
Tin,
Lead,
Silver,
Biſmuth,
Antimony,
Mercury,
Arſenic,
Molybdena.

POTASH, SODA, AND AMMONIA.

Acids. Sulphuric,
Nitric,
Muriatic,
Phoſphoric,
Fluoric,
Oxalic,
Tartaric,
Arſenic,
Succinic,
Citric,
Lactic,
Benzoic,
Sulphurous
Acetic,
Mucic,
Boracic,
Nitrous,
Carbonic,
Prussic,
Oil,
Water,
Sulphur.

BARYTES.

Acids. Sulphuric,
Oxalic,
Succinic,
Fluoric,
Phoſphoric,
Mucic
Nitric,
Muriatic,
Suberic,
Citric,
Tartaric,
Arſenic,
Lactic,
Benzoic,
Acetic
Boracic
Sulphurous,
Nitrous,
Carbonic,
Pruſſic,
Sulphur,
Phoſphorus,
Water,
Fixed Oils.

STRONTITES.

Acids. Sulphuric,
Phoſphoric,
Oxalic,
Tartaric,
Fluoric,
Nitric,
Muriatic,
Succinic,
Acetic,
Arſenic,
Boracic,
Carbonic,
Water.

LIME.

Acids. Oxalic,
Sulphuric,
Tartaric,
Succinic,
Phoſphoric,
Mucic,
Nitric,
Muriatic,
Suberic,

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* Vauquelin's Table of the affinity of the metals for oxygen, according to the difficulty with which their oxides are decompoſed by heat.

TABLE OF SIMPLE AFFINITY, CONTINUED.

Acids. Fluoric,
Arſenic,
Lactic,
Citric,
Malic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Pruſſic,
Sulphur,
Phoſphorus,
Water,
Fixed oil.

MAGNESIA.

Acids. Oxalic,
Phoſphoric,
Sulphuric,
Fluoric,
Arſenic,
Mucic,
Succinic,
Nitric,
Muriatic,
Tartaric,
Citric,
Malic ?
Lactic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Pruſſic,
Sulphur.

ALUMINE.

Acids. Sulphuric
Nitric,
Muriatic,

Oxalic,
Arſenic,
Fluoric,
Tartaric,
Succinic,
Mucic,
Citric,
Phoſphoric,
Lactic,
Benzoic,
Acetic,
Boracic,
Sulphurous,
Nitrous,
Carbonic,
Pruſſic.

SILEX.

Fluoric acid,
Potaſh.

OXIDE OF PLATINA.
———GOLD.*

Gallic acid.
Muriatic,
Nitric,
Sulphuric,
Arſenic,
Fluoric,
Tartaric,
Phoſphoric,
Oxalic,
Citric,
Acetic,
Succinic,
Pruſſic,
Carbonic,
Ammonia.

OXIDE OF SILVER.

Gallic acid,

Muriatic,
Oxalic,
Sulphuric,
Mucic,
Phoſphoric,
Sulphurous,
Nitric,
Arſenic,
Fluoric,
Tartaric,
Citric,
Lactic,
Succinic,
Acetic,
Pruſſic,
Carbonic,
Ammonia.

OXIDE OF MERCURY.

Gallic acid,
Muriatic,
Oxalic,
Succinic,
Arſenic,
Phoſphoric,
Sulphuric,
Mucic,
Tartaric,
Citric,
Malic,
Sulphurous,
Nitric,
Fluoric,
Acetic,
Benzoic,
Boracic,
Pruſſic,
Carbonic.

OXIDE OF LEAD.

Gallic,
Sulphuric,
Mucic,

Oxalic,
Arſenic,
Tartaric,
Phoſphoric,
Muriatic,
Sulphurous,
Suberic,
Nitric,
Fluoric,
Citric,
Malic,
Succinic,
Lactic,
Acetic,
Benzoic,
Boracic,
Pruſſic,
Carbonic,
Fixed oils,
Ammonia.

OXIDE OF COPPER.

Gallic,
Oxalic,
Tartaric,
Muriatic,
Sulphuric,
Mucic,
Nitric,
Arſenic,
Phoſphoric,
Succinic,
Fluoric,
Citric,
Lactic,
Acetic,
Boracic,
Pruſſic,
Carbonic,
Fixed alkalies,
Ammonia,
Fixed oils.

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[*] Omitting the oxalic, citric, succinic, and carbonic, and adding ſulphuretted hydrogen after ammonia.

TABLE OF SIMPLE AFFINITY, CONTINUED.

OXIDE OF ARSENIC.

Gallic,
Muriatic,
Oxalic,
Sulphuric,
Nitric,
Tartaric,
Phoſphoric,
Fluoric,
Succinic,
Citric,
Acetic,
Pruſſic,
Fixed alkalies,
Ammonia,
Fixed oils,
Water.

OXIDE OF IRON.

Gallic,
Oxalic,
Tartaric,
Camphoric,
Sulphuric,
Mucic,
Muriatic,
Nitric,
Phoſphoric,
Arſenic,
Fluoric,
Succinic,
Citric,
Lactic,
Acetic,
Boracic,
Pruſſic,
Carbonic.

OXIDE OF TIN.

Gallic,
Muriatic,
Sulphuric,
Oxalic,
Tartaric,
Arſenic,
Phoſphoric,
Nitric,
Succinic,
Fluoric,
Mucic,
Citric,
Lactic,
Acetic,
Boracic,
Pruſſic,
Ammonia.

OXIDE OF ZINC.

Gallic,
Oxalic,
Sulphuric,
Muriatic,
Mucic,
Nitric,
Tartaric,
Phoſphoric,
Citric,
Succinic,
Fluoric,
Arſenic,
Lactic,
Acetic,
Boracic,
Pruſſic,
Carbonic,
Fixed alkalies,
Ammonia.

OXIDE OF ANTIMONY.

Gallic,
Muriatic,
Benzoic,
Oxalic,
Sulphuric,
Nitric,
Tartaric,
Mucic,
Phoſphoric,
Citric,
Succinic,
Fluoric,
Arſenic,
Lactic,
Acetic,
Boracic,
Pruſſic,
Fixed alkalies,
Ammonia.

SULPHURIC ACID.
PRUSSIC.*

Barytes,
Strontites,
Potaſh,
Soda,
Lime,
Magneſia,
Ammonia,
Glucine,
Yttria,
Alumine,
Zircon,
Metallic oxides

SULPHUROUS ACID.
SUCCINIC.†

Barytes,
Lime,
Potaſh,
Soda,
Strontites,
Magneſia,
Ammonia,
Glucine,
Alumine,
Zircon,
Metallic oxides.

PHOSPHORIC ACID.
CARBONIC.‡

Barytes,
Strontites,
Lime,
Potaſh,
Soda,
Ammonia,
Magneſia,
Glucine,
Alumine,
Zircon,
Metallic oxides,
Silex.

PHOSPHOROUS ACID.

Lime,
Barytes,
Strontites,
Potaſh,
Soda,
Ammonia,
Glucine,
Alumine,
Zircon,
Metallic oxides.

NITRIC ACID.
MURIATIC ——‖

Barytes,
Potaſh,
Soda,
Strontites,
Lime,
Magneſia,

---

* With the omission of all after ammonia.

† Ammonia should come before magnesia; and stronites, glucine, and zircon, should be omitted.

‡ Magnesia should stand above ammonia, and alumina and silica should be omitted.

‖ Ammonia should stand above magnesia.

TABLE OF SIMPLE AFFINITY, CONTINUED.

Ammonia,
Glucine,
Alumine,
Zircon,
Metallic oxides.

FLUORIC ACID.
BORACIC ——*
ARSENIC ——†
TUNGSTIC——

Lime,
Barytes,
Strontites,
Magneſia,
Potaſh,
Soda,
Ammonia,
Glucine,
Alumine,
Zircon,
Silex.

ACETIC ACID.
LACTIC ——
SUBERIC ——‡

Barytes,
Potaſh,
Soda,
Strontites,
Lime,
Ammonia,
Magneſia,
Metallic oxides,
Glucine,
Alumine,
Zircon.

OXALIC ACID.
TARTARIC ——
CITRIC ——‖.

Lime,
Barytes,
Stronites,
Magneſia,
Potaſh,
Soda,
Ammonia,
Alumine,
Metallic oxides,
Water,
Alcohol.

BENZOIC ACID.

White oxide of Arſenic,
Potaſh,
Soda,
Ammonia,
Barytes,
Lime,
Magneſia,
Alumine.

CAMPHORIC ACID.

Lime,
Potaſh,
Soda,
Barytes,
Ammonia,
Alumine,
Magneſia.

FIXED OIL.

Lime,
Barytes,
Potaſh,
Soda,
Magneſia,
Oxide of Mercury,
Other metallic oxides,
Alumine.

ALCOHOL.

Water,
Ether,
Volatile oil,
Alkaline ſulphurets.

SULPHURETTED HYDROGEN.

Barytes,
Potaſh,
Soda,
Lime,
Ammonia,
Magneſia,
Zircon.

---

* Silex should be omitted, and, instead of it, water and alcohol be inserted.
† Except silex.
‡ With the omission of strontites, metallic oxyds, glucine, and zircon.
‖ Zircon after alumine.

EXPLANATION OF THE PLATES.

The twelve firſt Plates repreſent various articles of chemical apparatus, all of which have been particularly deſcribed in Appendix I. It will therefore only be neceſſary in this place to give the names of the different articles, and refer the reader to the ſame names in the firſt Appendix for their conſtruction and uſes.

Plate 1.

Fig. 1. A long-necked Retort for procuring gaſſes.
2. A Tubulated Retort.
3. An Adopter.
4. A tubulated or quilled Receiver.
5. A common Retort for diſtillation.
6. A Balloon Receiver.
7. A ribbed glaſs Funnel.
8. A ſmall Matraſs.
9. An earthenware Evaporating veſſel.
10. An iron Sand-Bath-pot.
11. A tubulated Retort, into which fits
12. An Acid-Holder.
13. 14, 15. Proof Bottles.
16. A plain Jar.
17. A Bell Receiver.
18. A graduated or Eudiometer Jar.
19. A lipped Jar for mixtures, &c.
20. A Precipitating Glaſs.
21. A lipped Glaſs for mixtures, &c.
22, 23, 24. A common Crucible with its Cover and its Stand.
25, 26, 27. A round Crucible with a Cover and Stand.
28, 29. Cupels, round and four-ſided.
30. A Muffle.

Plate 2.

31. A common Still fitted to a portable furnace.
32. A Worm-Tub or Refrigeratory.
33, 34. A copper Alembic with water bath and refrigeratory.
35. A ſmall Alembic.
36. A ſet of Aludels.
37. An Apparatus for digeſtions, an improvement on
38. A Pelican.
39. A glaſs Alembic and globe Receiver.
40. A ſeparatory Funnel.
41. A Gun-Barrel Apparatus uſed for procuring Hydrogen, &c.

Plate 3.

42, 43, 44, 45. Mr. Pepys's improved Woulfe's Apparatus, which may alſo be uſed as a Gas-ſaturating apparatus.
46. Dr. Nooth's Gas-ſaturating apparatus.
47. Dr. Hamilton's ditto
48. A flat-bottomed Matraſs.

PLATE 4.

Fig. 49, 50, 51. A pneumatic Water-Trough.
52. A round ditto ditto
53. A mercurial Trough.
54. Mr. Leſlie's differential Thermometer.
55. Dr. Hope's Eudiometer.
56. Mr. Davy's ditto
57, 58, 59. Woulfe's apparatus of various conſtruction.
60. A Tube of ſafety.

PLATE 5.

61, 62. A common Gazometer or Gas-Holder.
63. A hollow Gazometer.

PLATE 6.

64. Mr. Pepys's Gazometer.
65. A ſtand, convenient for Filtration ſupporting funnels and jars.
66. An improved Acid-Holder
67. An improved Detonating Jar or Volta's Eudiometer.
68. A flexible Tube belonging to Fig. 64.

PLATE 7.

69 to 76. Blow-pipe apparatus of various kinds.

PLATE 8.

77 to 82. A Black's Furnace with its various parts.
83, 84, 85. A Muffle-furnace for intenſe heat.

PLATE 9.

86 to 89. A portable Blaſt-furnace.
90, 91. A reverberatory Furnace.

PLATE 10. (*Frontiſpiece.*)

A view of the range of Furnaces in Mr. Pepys's Laboratory.

PLATE 11.

Section and Plan of Plate 10.

PLATE 12.

92. Conſtruction of the door to ſome of the Furnaces of Plate 10.
93. Flat-bottomed Sand-bath belonging to the ſame.
94. Section of the Furnace for naked diſtillation of the ſame.
95 to 98. Fire Tongs of various forms.

Plates 13, 14, & 15,

Illustrative of Crystallography.

The object in ſelecting the following figures with their deſcriptions (which are thoſe of actual cryſtals) is principally to familiarize the young mineralogiſt with the terms of cryſtallography: the reader therefore will not expect to find delineations of all or nearly all the forms of cryſtallization to which minerals are ſubject. A ſufficient variety, however, has, we truſt, been ſelected to enable the ſtudent, with a little practice, to comprehend, without much difficulty, the moſt complex of the forms that are deſcribed in the body of this work.

All proper cryſtals are rectilinear ſolids bounded by plane ſurfaces or *faces:* the line of junction, or that in which two faces unite, is called an *edge*; and the point in which three or more faces unite is called a *ſolid angle.*

In every cryſtal there are two oppoſite ends or extremities: if they terminate in ſolid angles they are called *ſummits*, if in ſurfaces they are called *baſes*. The faces compoſing the ſummit are called *acuminating planes* or faces of the *terminal pyramid*; and the edges by which they unite are called *edges of the pyramid.*

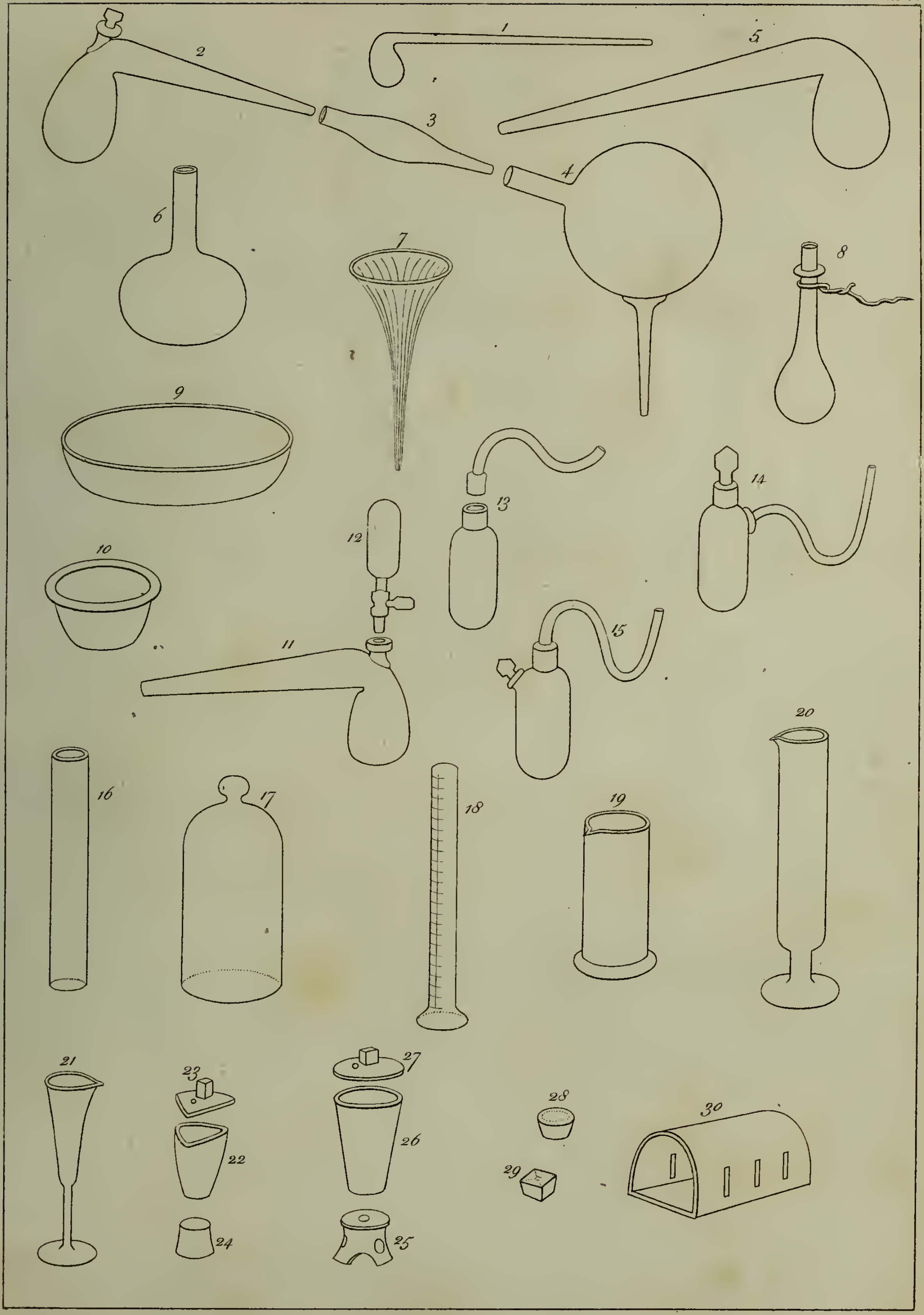
The plane conſtituting each baſe is called ſimply the *baſe*, and the lines by which it is bounded are called the *edges of the baſe.* The faces intervening between the two baſes are called *lateral faces*, and the lines by which theſe faces come in contact with each other are called *lateral edges.*

If an edge or ſolid angle is cut off by the interpoſition of one plane, ſuch angle or edge is ſaid to be *truncated*, or *replaced by a ſecondary plane:* but if it is cut off by the interpoſition of two planes, the angle or edge is ſaid to be *bevilled* or *replaced by two ſecondary planes*; and the line by which theſe ſecondary planes join each other, is called the *bevilling edge.*

Fig. 1 is the regular Tetrahedron, or a trihedral pyramid.
2 is the preceding with the ſolid angles truncated or replaced by triangular planes. *a* Truncatures.
3 is No. 1. with all the edges truncated. *a* Truncatures.
4 is No. 1. with the edges bevilled. *a* Bevilling edges.
5 is the preceding, in which the bevilling planes have entirely obliterated the original ones.
6 is the Pyramidal Octohedron, compoſed of two tetrahedrons joined baſe to baſe. *a* Summits, *b* acuminating faces, *c* edges of the common baſe.
7 is the preceding, with the ſummits truncated.
8 is No. 7. with ſecondary pyramids placed on the truncatures.
9 is No. 6. truncated on the edges.
10·is No. 6. bevilled on the ſolid angles.
11 is No. 6. truncated on the ſolid angles, and bevilled and truncated on the edges.
12 is a pyramidal octohedron, with wedge-ſhaped ſummits and a rhomboidal common baſe. *a* Edges of the common baſe.
13 14 are the Rhomboid, which may be conſidered either as a tetrahedral priſm, or as compoſed of two trihedral pyramids with rhombic faces.
15 is No. 14 truncated on all the ſolid angles.
16 is a rhomboidal priſm with dihedral ſummits.
17 is the preceding, with the alternate ſolid angles bevilled.
18 is a rhomboidal priſm, truncated on the obtuſe lateral edges. *a a* Truncations.
19 is the Cube, which may alſo be conſidered as a rectangular priſm.
20 is the preceding, with all the edges truncated.
21 is No. 19, with all the ſolid angles truncated.
22 is No. 19. bevilled on all the edges.
23 is a Rectangular Priſm, terminated by tetrahedral pyramids.

Fig. 24 is the preceding, bevilled on the ſolid angles of the priſm.
25 is No. 23. truncated on the lateral edges.
26 is an oblique rectangular priſm deeply bevilled on the ſolid angles.
27 is a rectangular priſm with rhomboidal ſummits.
28 is the preceding, with the lateral edges truncated.
29 is a tetrahedral table bevilled on the edges.
30 is the RHOMBOIDAL DODECAHEDRON.
31 is the preceding, with all the edges truncated.
32 is an elongated acute rhomboidal dodecahedron.
33 is the preceding, with the ſummits truncated.
34 is No. 32. with the edges of the ſummit bevilled and truncated.
35 is the regular HEXAHEDRAL PRISM.
36 is the preceding, terminated by hexahedral pyramids.
37 is No. 36. with the pyramids deeply truncated.
38 is No. 37. with the ſolid angles alſo truncated.
39 is No. 36. with the lateral edges truncated.
40 is a hexahedral priſm, with three ſuperpoſed pyramids on each baſe, the two lower of which are deeply truncated.
41 is the PYRAMIDAL DODECAHEDRON.
42 is the preceding, with the ſummits deeply truncated, and ſecondary pyramids ſet on the truncatures.
43 is the EICOSAHEDRON, with triangular faces.
44 is a *geniculated* OCTOHEDRAL PRISM.

Plate 1.



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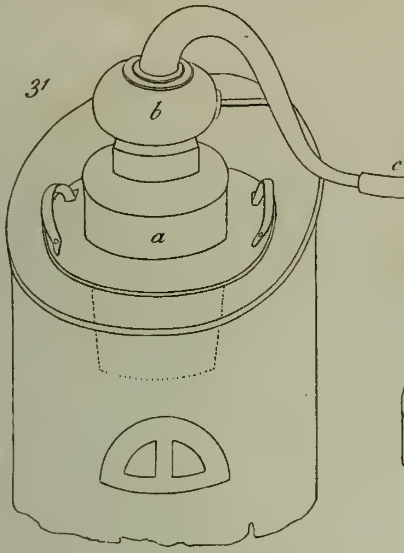

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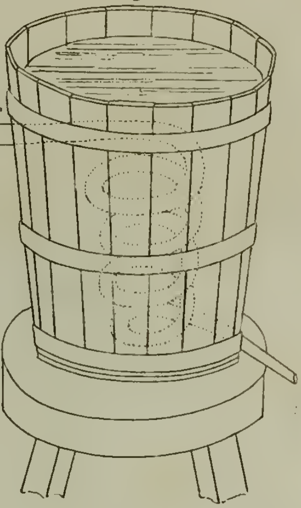

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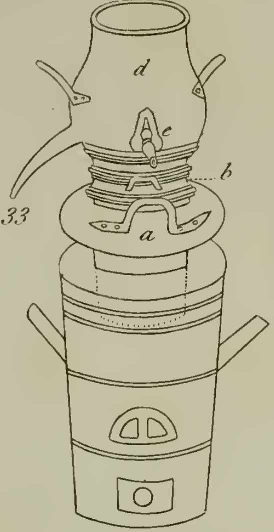

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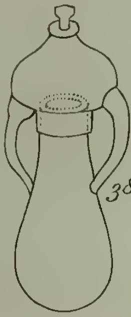

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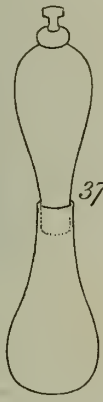

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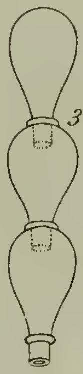

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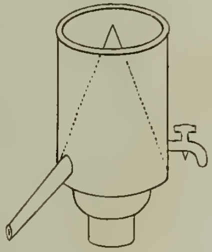

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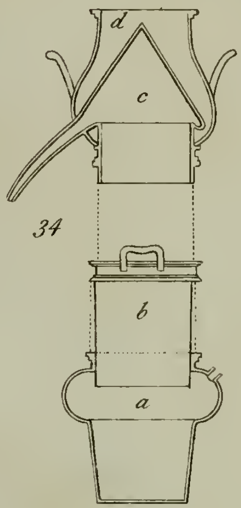

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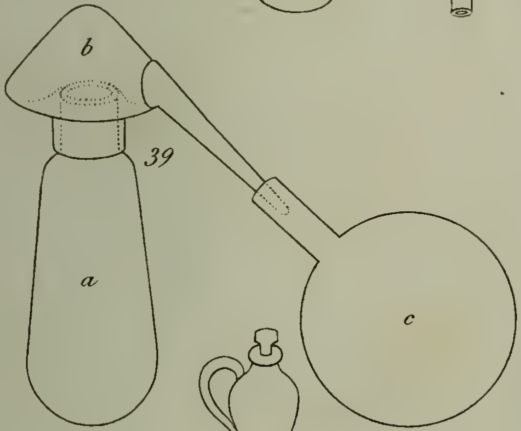

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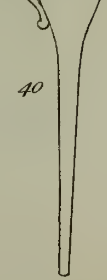

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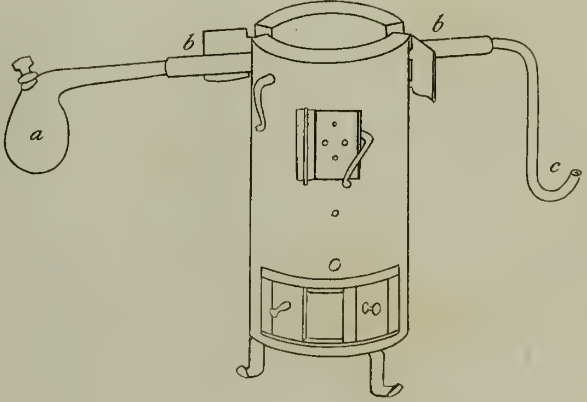

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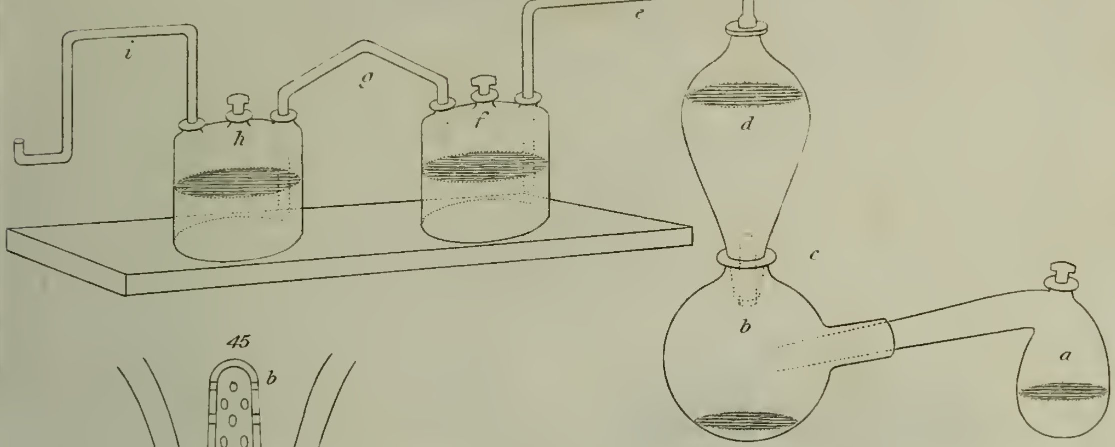

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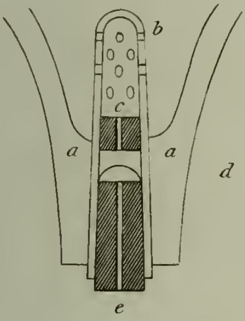

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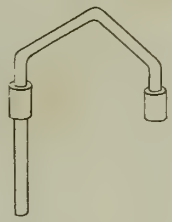

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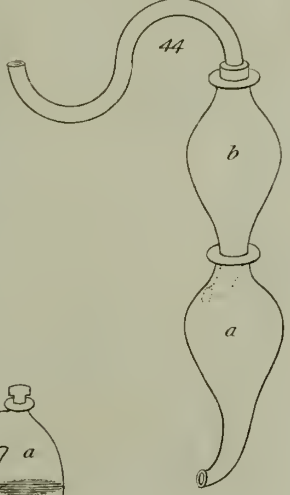

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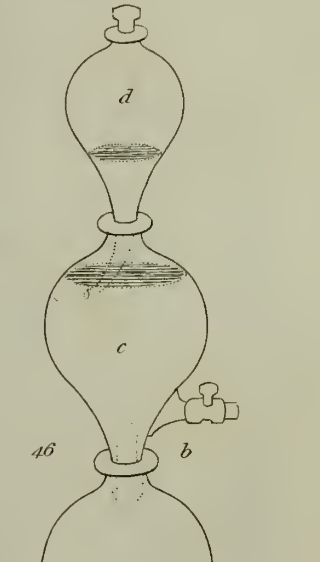

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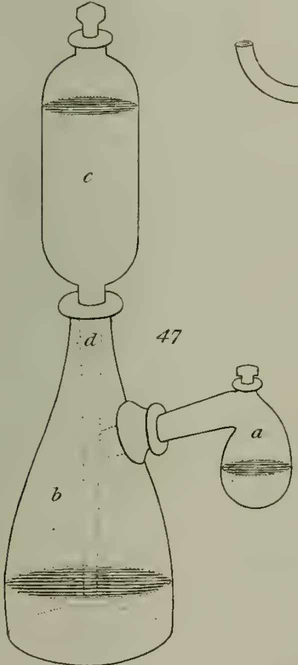

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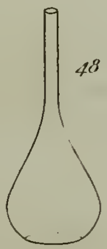

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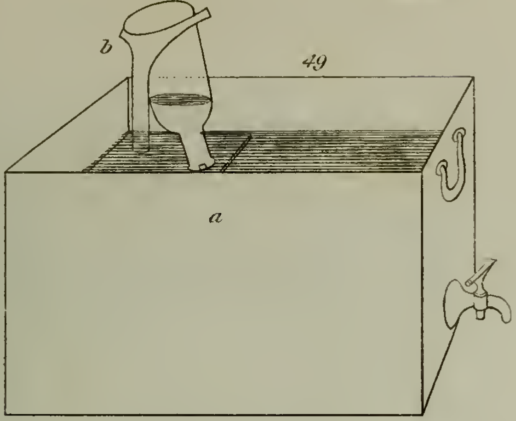

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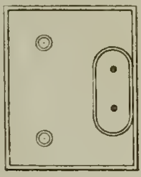

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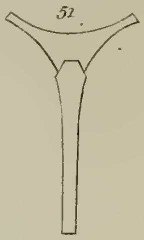

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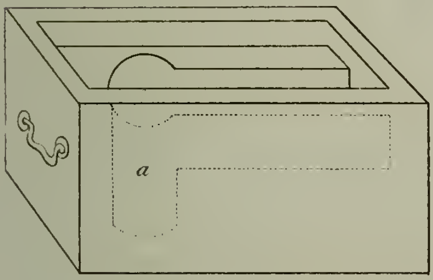

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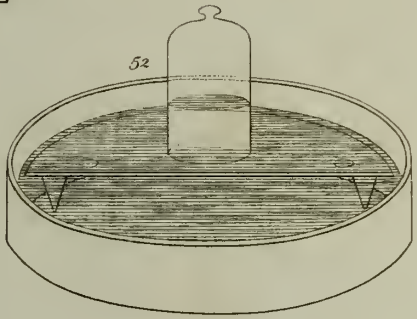

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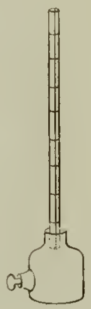

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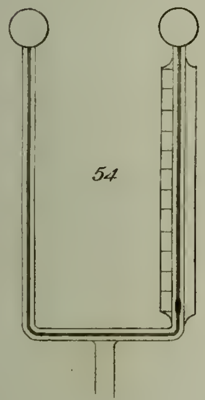

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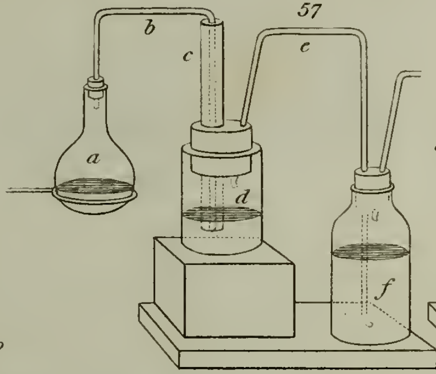

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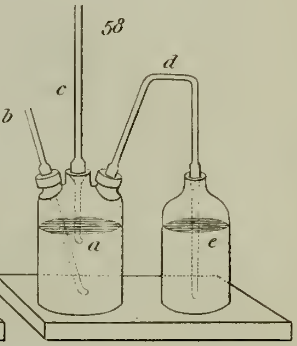

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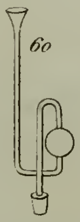

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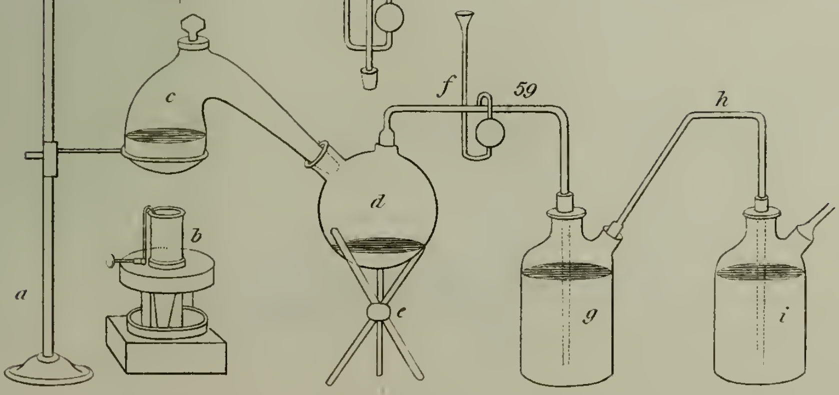

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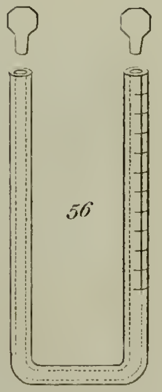

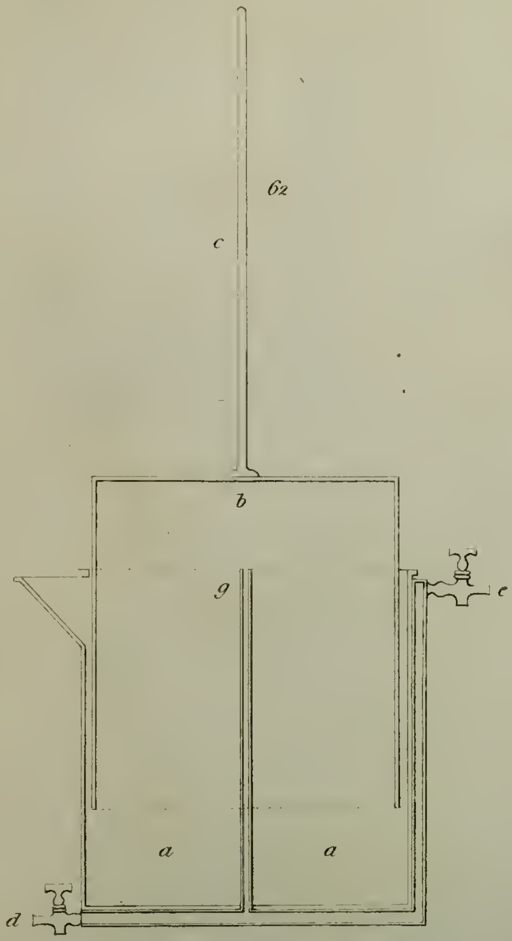

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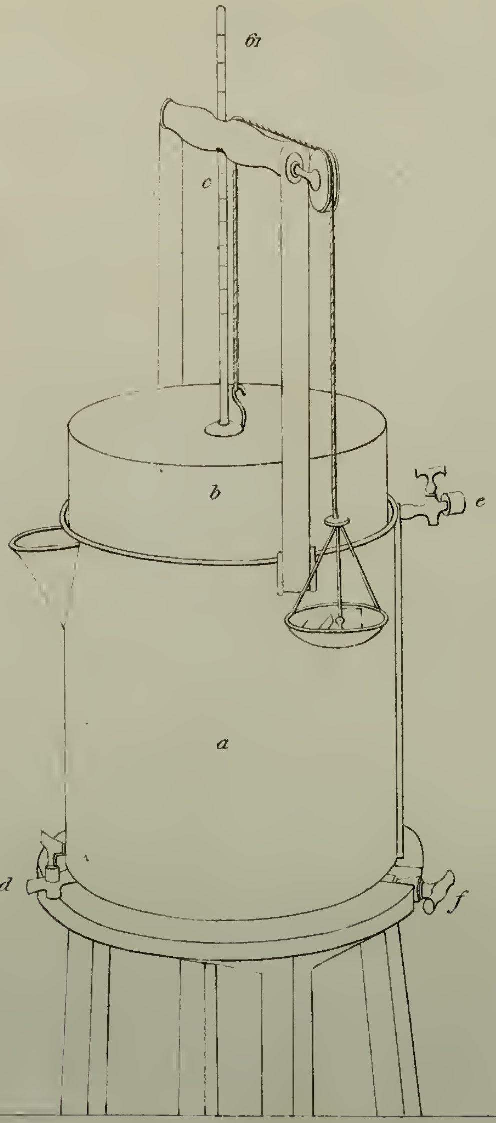

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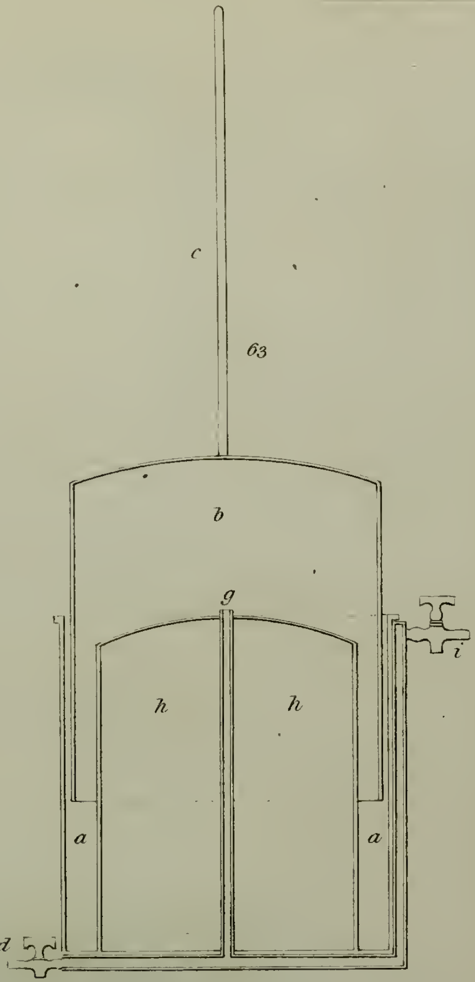

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Plate 6.

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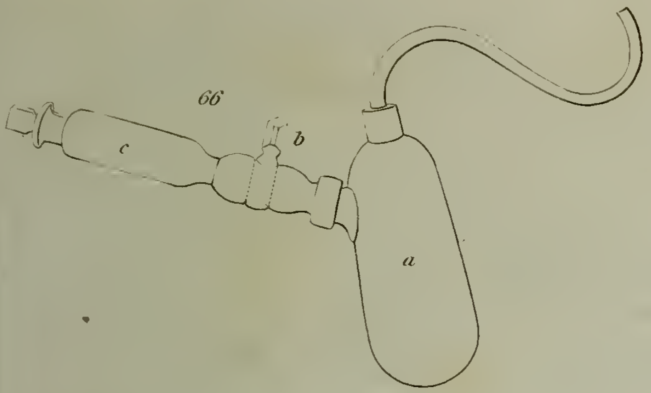

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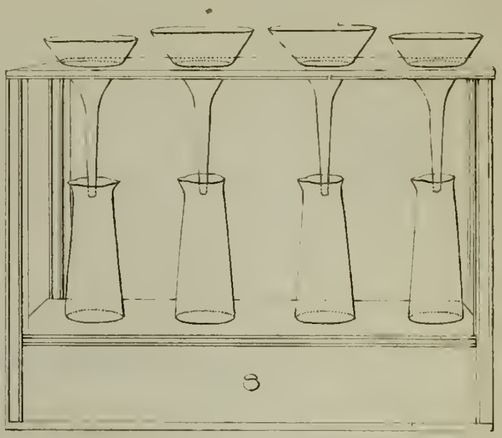

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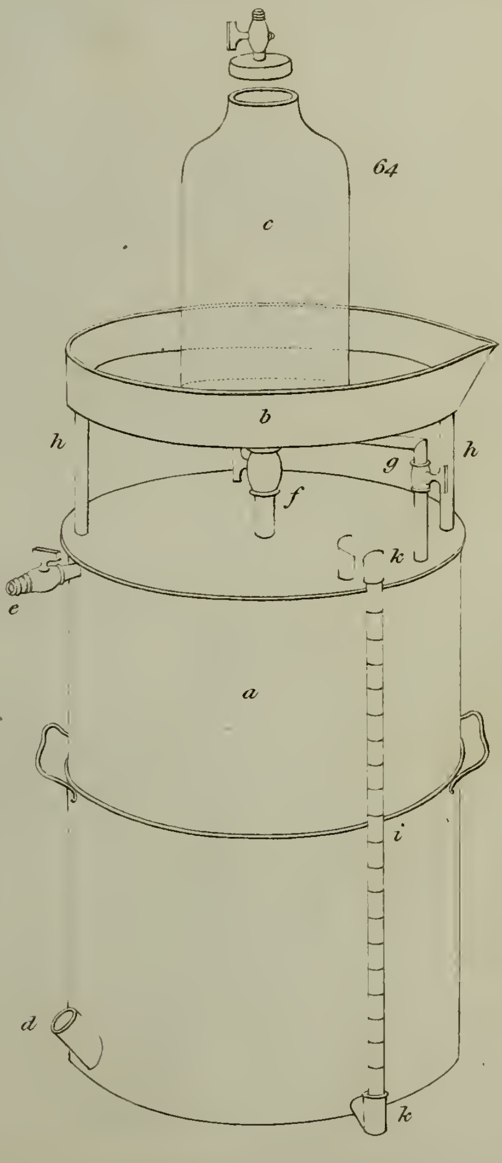

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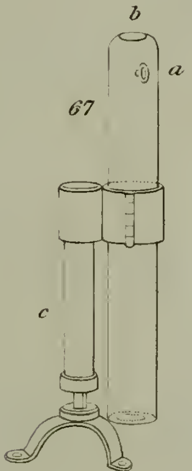

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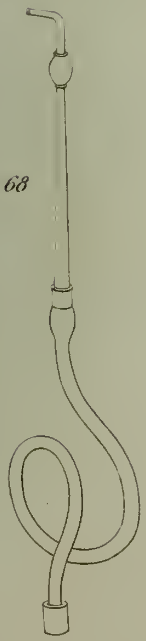

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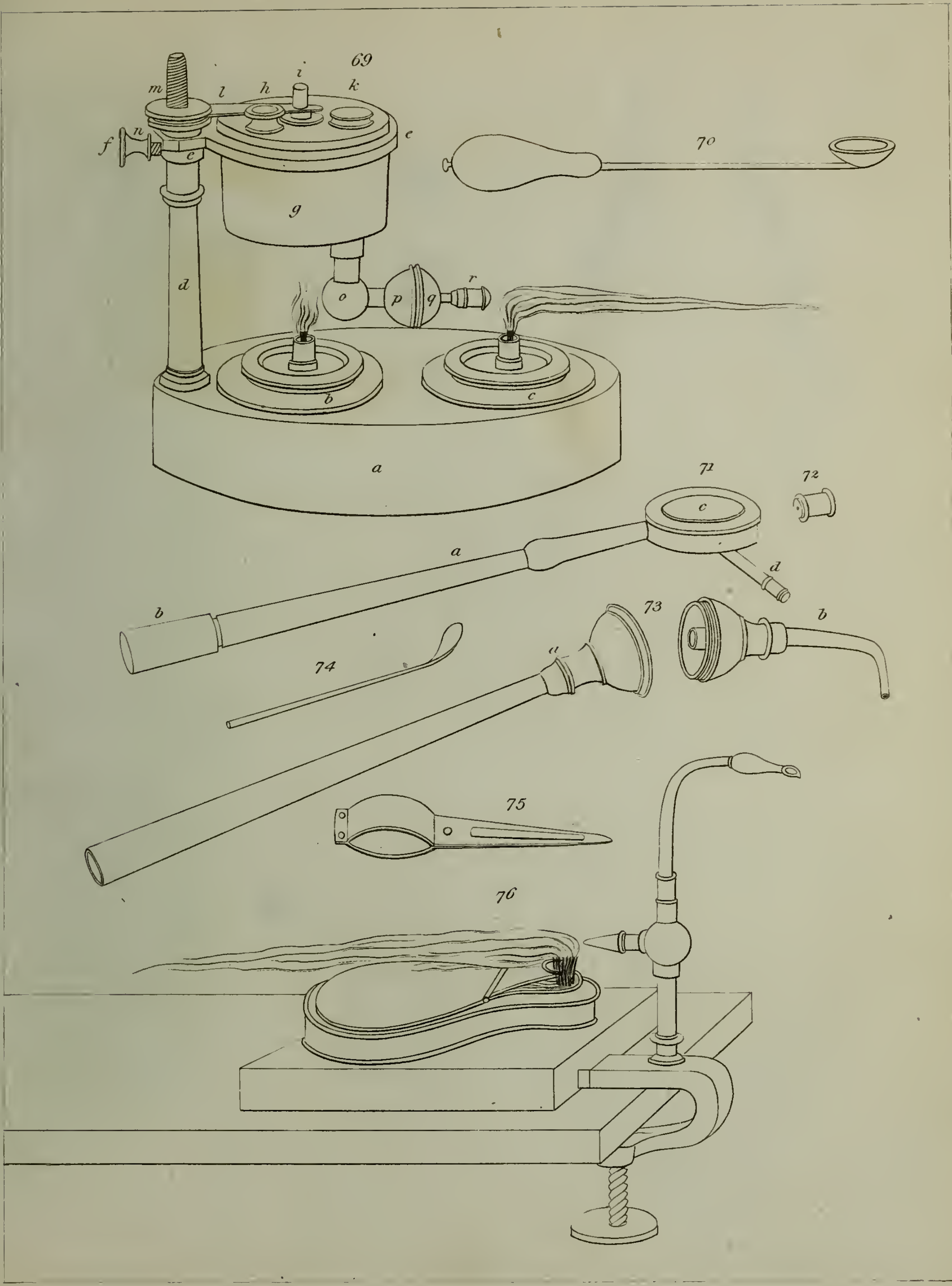

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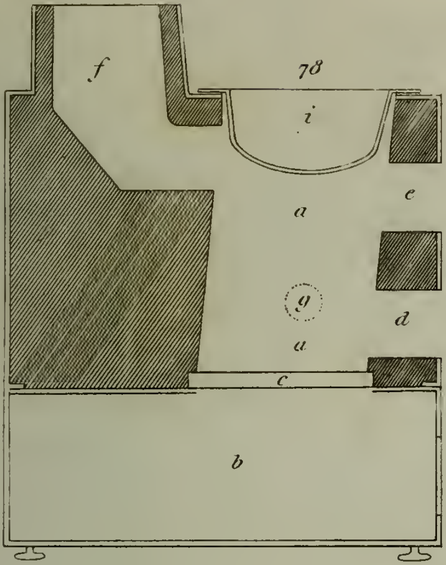

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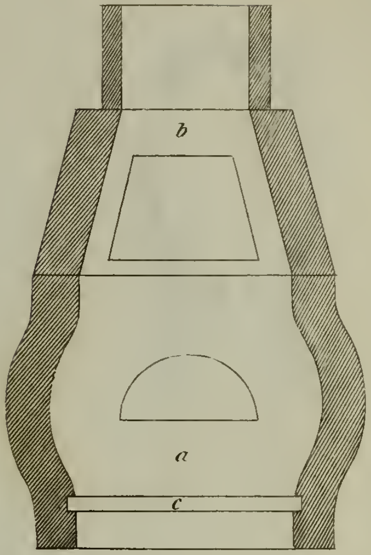

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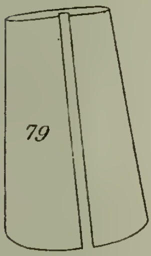

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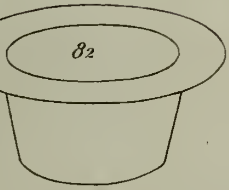

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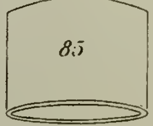

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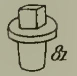

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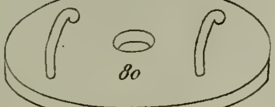

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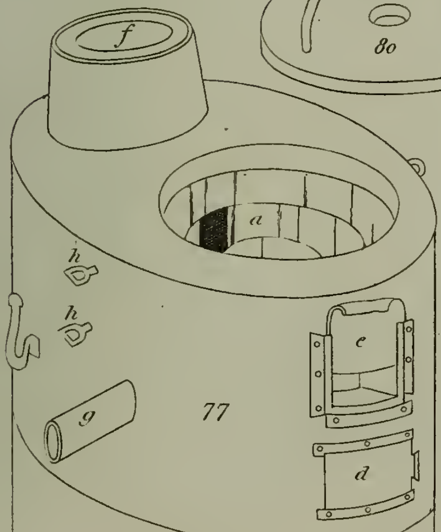

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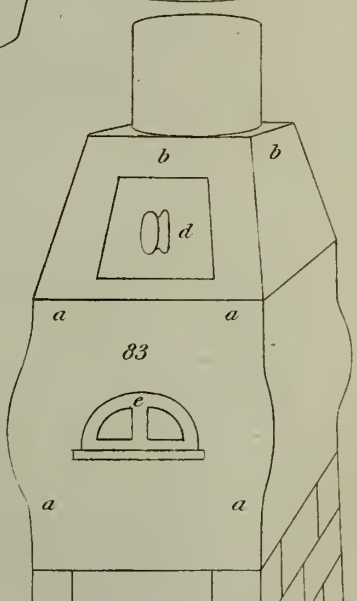

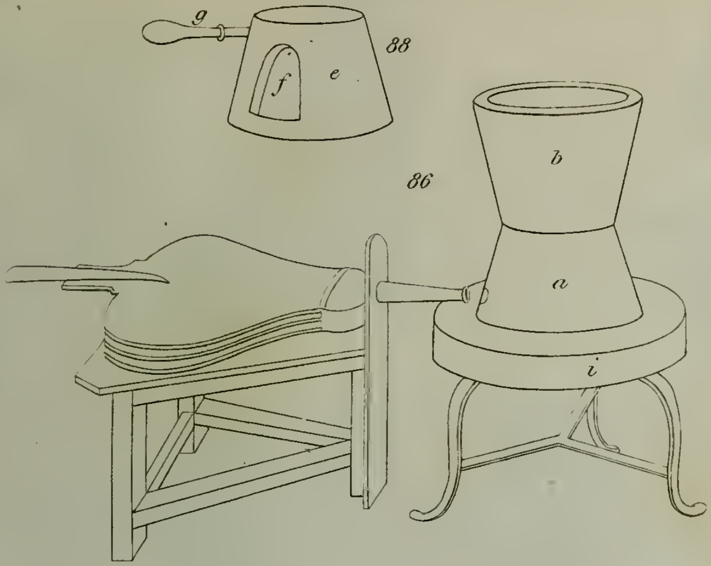

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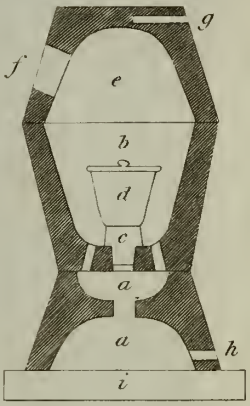

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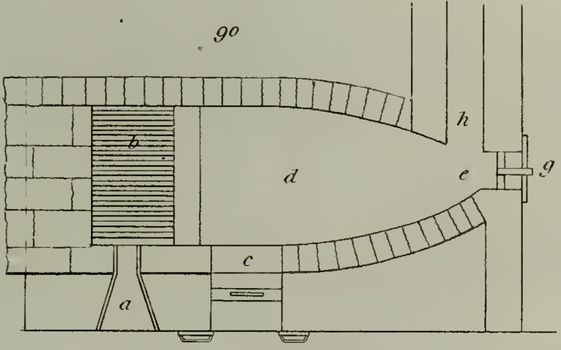

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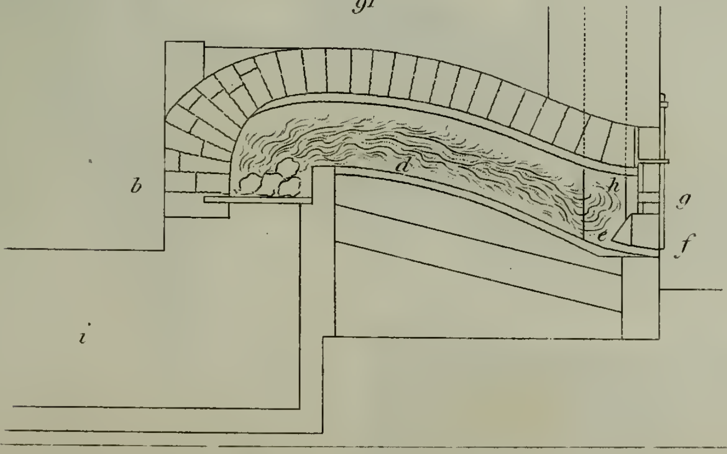
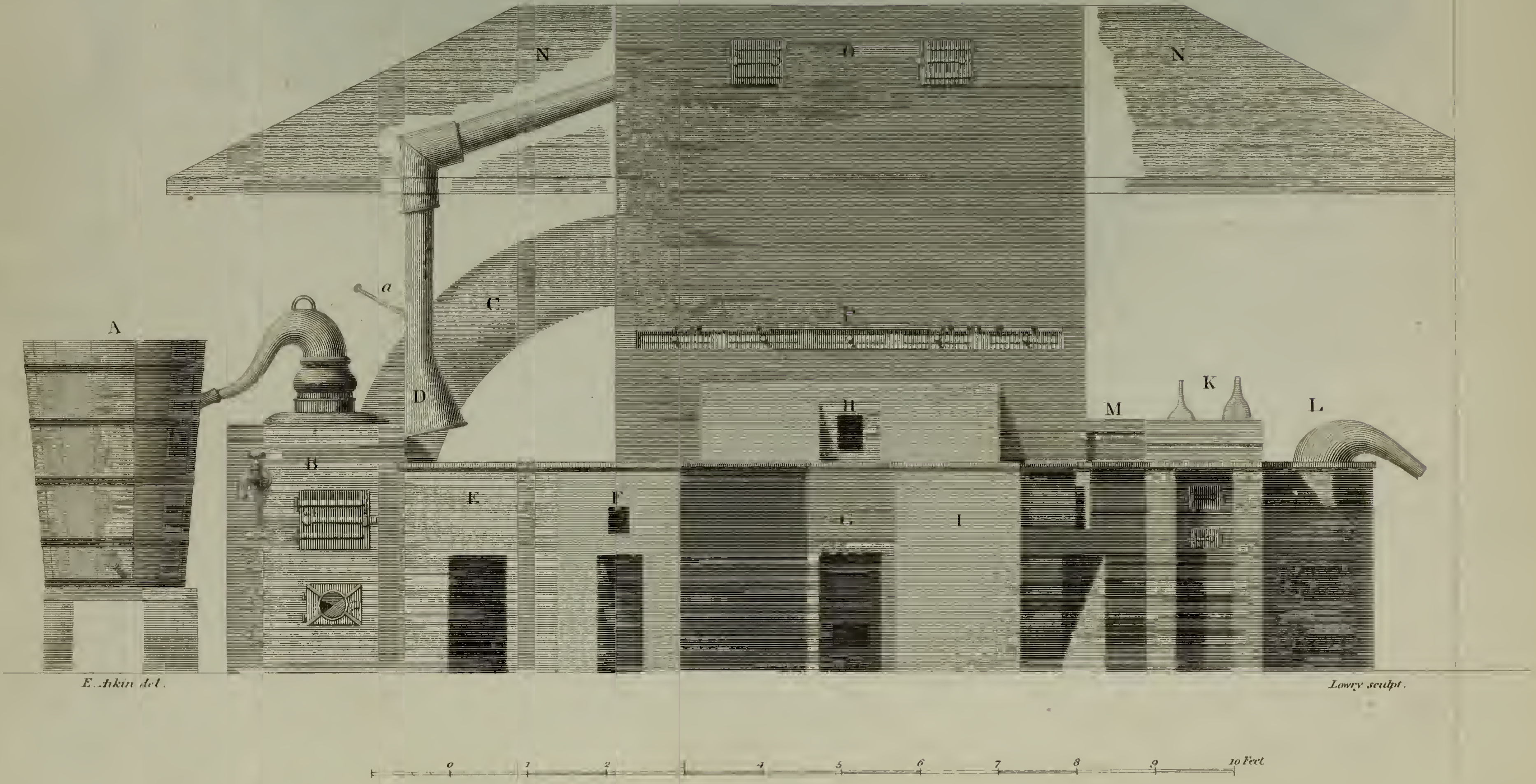


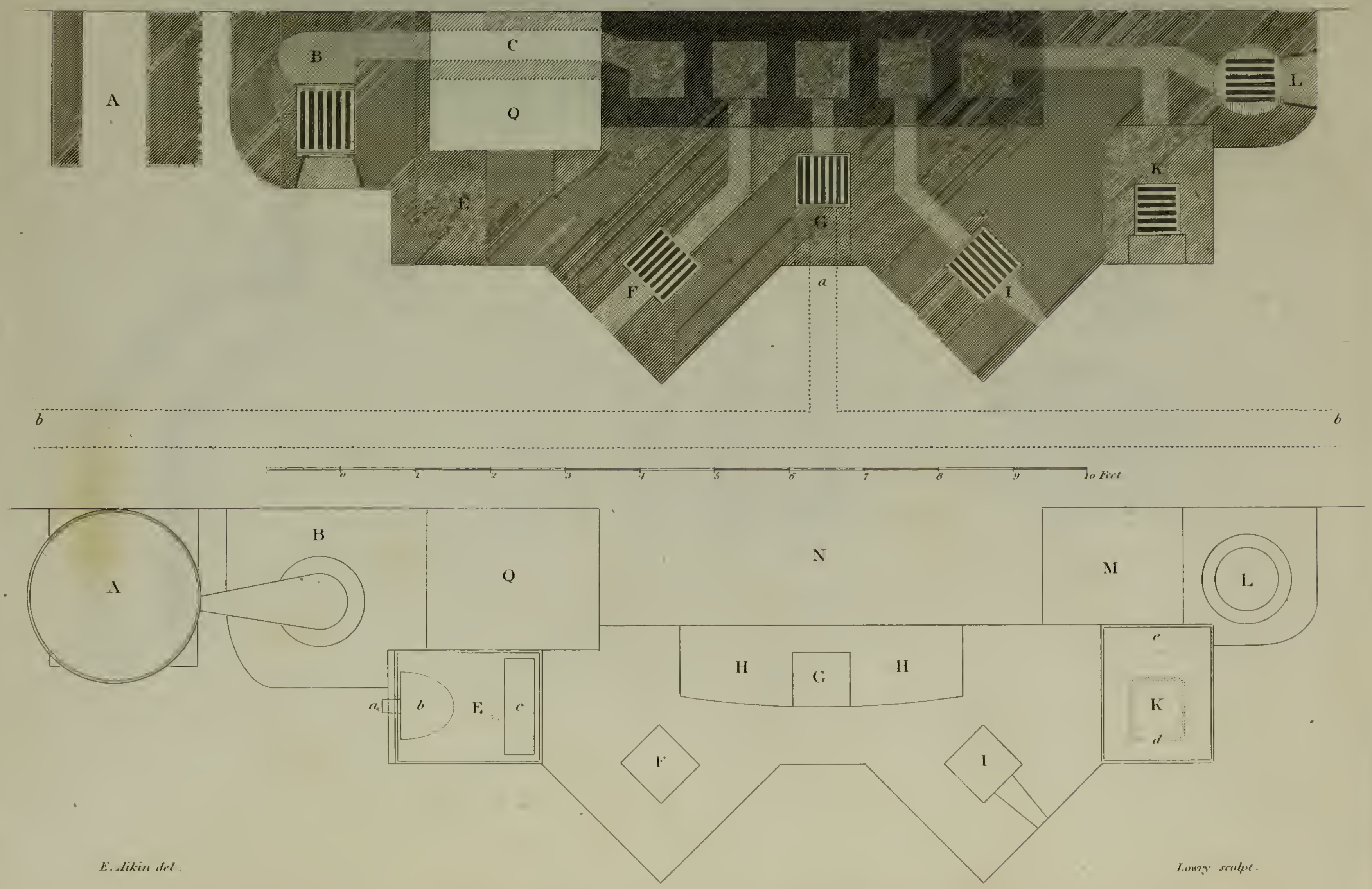


E. Aikin del.

Lowry sculpt.

Arrangement of the Furnaces in Mr Pepys's Laboratory.

Plate II.



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Arrangement of the Furnaces in Mr. Pepys's Laboratory.

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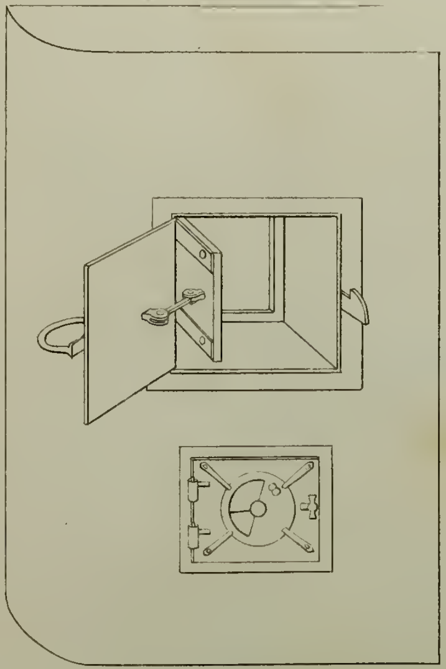

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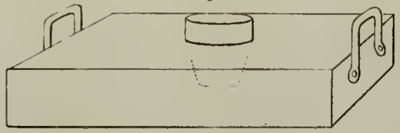

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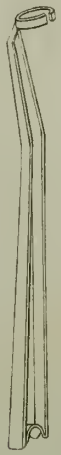

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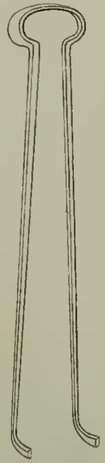

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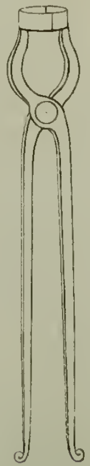

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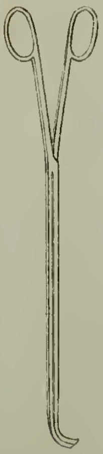

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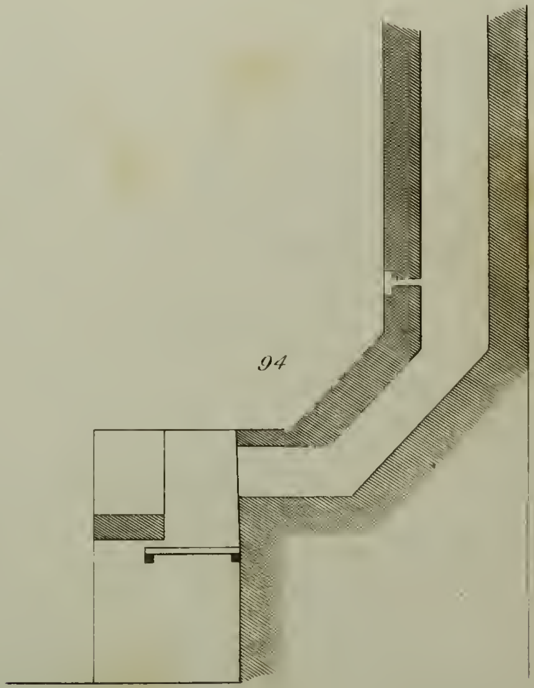

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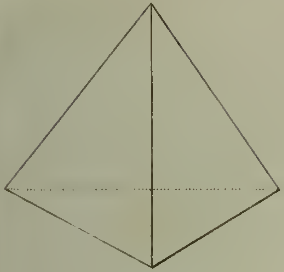

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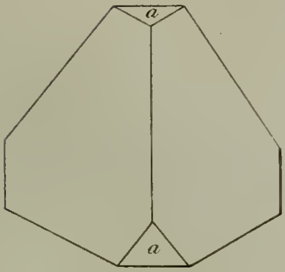

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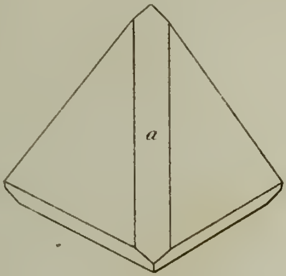

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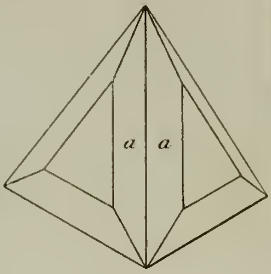

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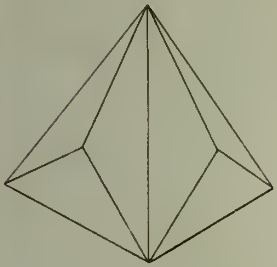

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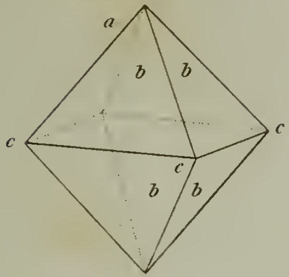

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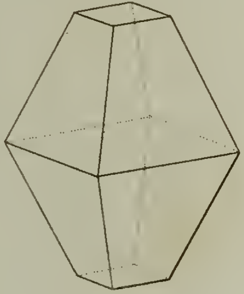

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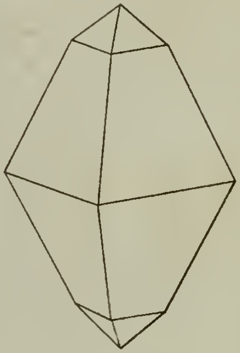

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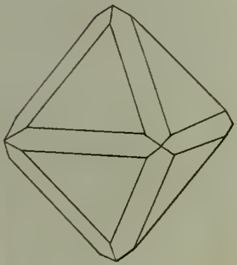

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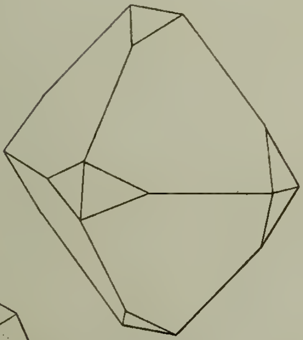

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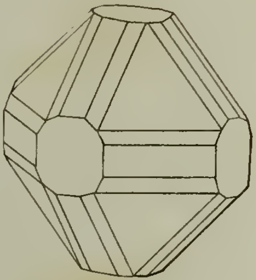

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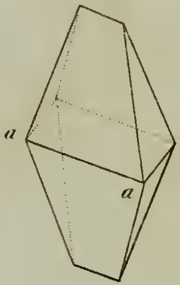

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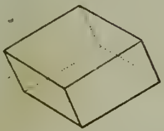

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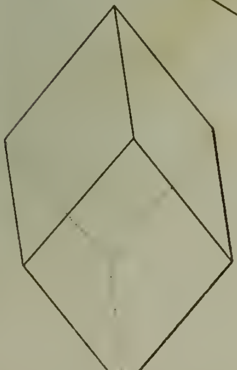

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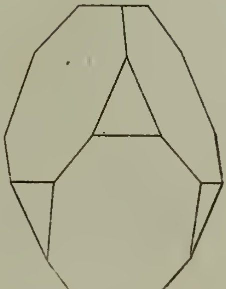

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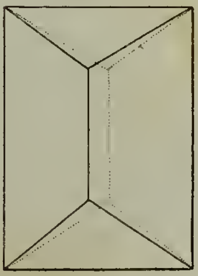

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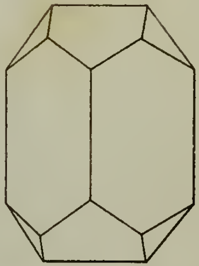

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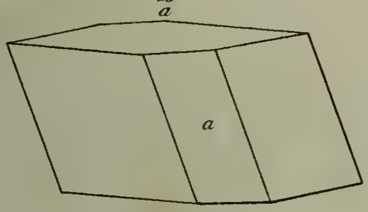

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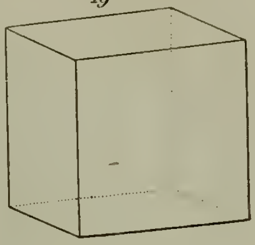

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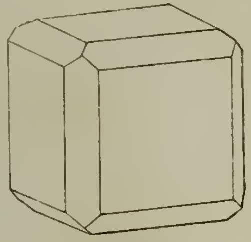

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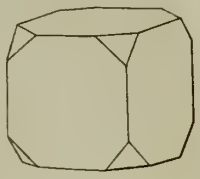

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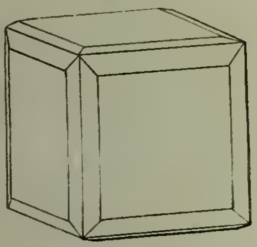

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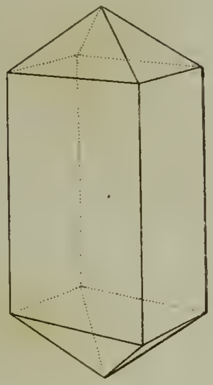

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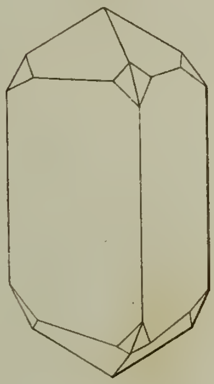

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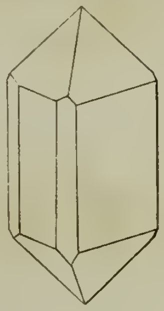

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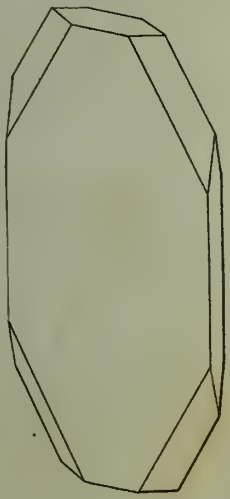

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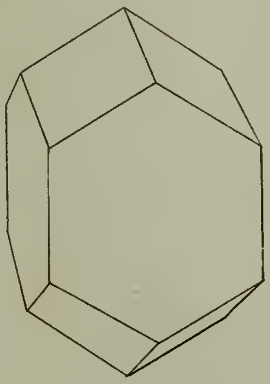

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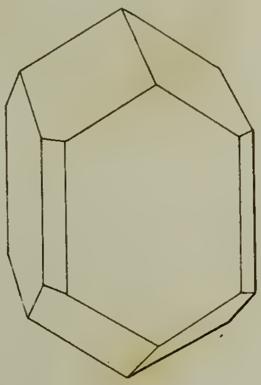

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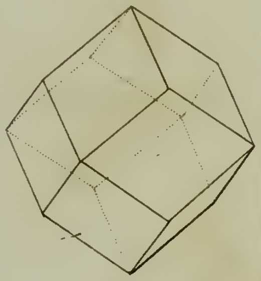

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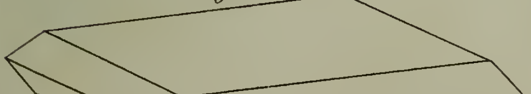

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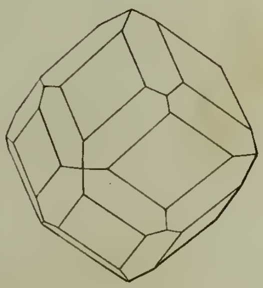

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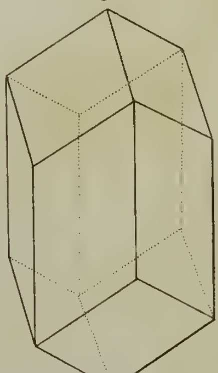

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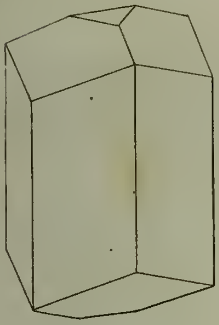

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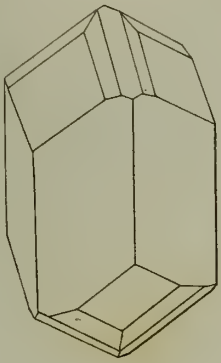

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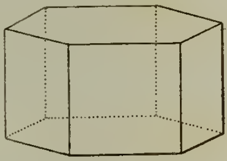

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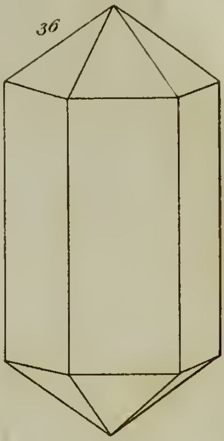

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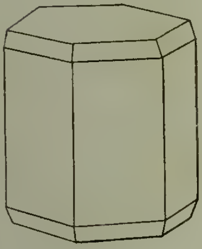

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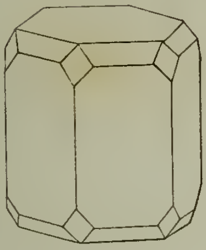

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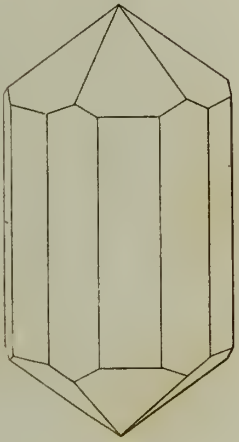

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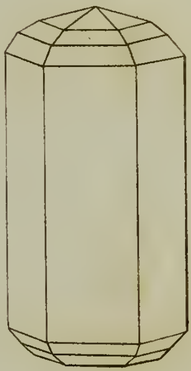

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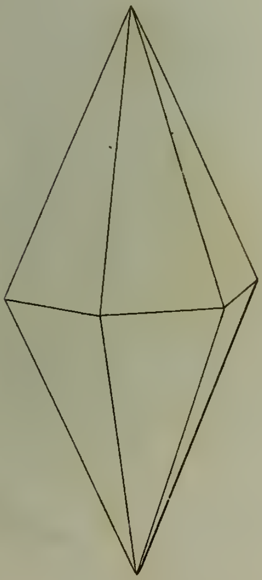

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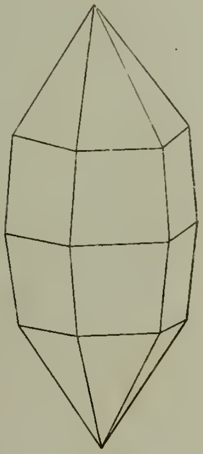

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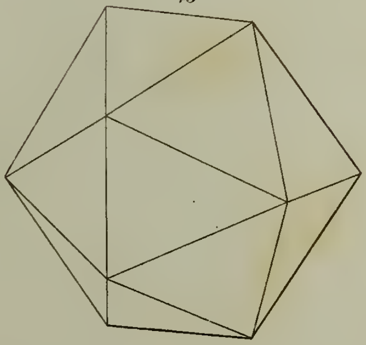

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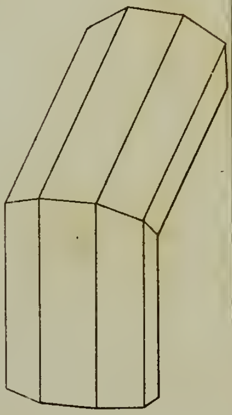

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INDEX.

N. B.—*Only thoſe articles are introduced in this Index which will not be readily found in their proper place in the body of the work. The figures that are not preceded by Roman numerals imply the pages of the firſt volume. Appendix I. requires no Index, and a Table of Contents is prefixed to Appendix II. relating to weights and meaſures, and other uſeful tables.*

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Printed by Wm. Phillips, George Yard, Lombard Street.